The Influence of Facial Parameters on Orthognathic Patient, Layperson and Clinician Perceived Attractiveness

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Abstract

Purpose: To undertake an objective and quantitative evaluation of how the variation of facial parameters influences perceived attractiveness.

Methods:

Part 1 (chapter 3): The craniofacial height of an idealized image was altered from 1/6 to 1/10 of standing height, creating 10 images shown in random order to 89 observers (74 laypeople; 15 clinicians), who ranked the images from most to least attractive.

Part 2 (chapters 4-8): Assessing the influence of lower facial parameters on perceived attractiveness.

Idealized facial images were created. Specific parameters were incrementally altered, creating a range of images, rated on a Likert scale by 185 observers: pre-treatment orthognathic patients (n=75), laypeople (n=75) and clinicians (n=35).

Part 3 (chapter 9): A longitudinal study assessing the effects of orthognathic surgery on perceptions of attractiveness. The images from chapter 8 were rated by 50 orthognathic patients at T1 (pre-treatment) and T2 (6-months following debond).

Results:

Part 1: A proportion of 1/7.5 was perceived as the most attractive (range: 1/7 to 1/8.5). Images perceived as most unattractive had a proportion of 1/6 and 1/10.

Part 2:

Chin height: The classical lower facial canon may be used as an 'ideal' proportional ratio. Variations within a given range were largely unnoticed, i.e. between 30% chin to lower anterior face height (LAFH) (male and female), up to 40% (males) and 50% (females). Surgery was desired with greater variations in chin height: >50% and <20-23% of LAFH (males), >58% and <20-22% of LAFH (females). Clinician and patient ratings were similar and more critical than laypeople.

Mandibular and chin point asymmetry: 10-mm is perceived as significant; at 5-mm and below, it is largely unnoticed. The greater the degree of asymmetry above 10-mm, the greater the desire for correction. Clinician and patient ratings were similar and more critical than laypeople.

Lower face convexity: A straight profile is perceived as most attractive and greater degrees of convexity or concavity deemed progressively less attractive. A range of 10°

to -12° may be acceptable; beyond these values surgical correction is desired. Patients are most critical, and clinicians are more critical than laypeople.

Chin prominence: An 'ideal' sagittal position with soft tissue pogonion on or just behind a true vertical line through subnasale may be used. Retrusion or protrusion up to 4-mm is unnoticeable. Surgery is desired for protrusions greater than 6-mm and retrusions greater than 10-mm. The overall direction of aesthetic opinion appears to be the same for all observer groups.

Mandibular prominence: Retrusion up to − 4 mm or protrusion up to 2-mm was unnoticeable. Surgery was desired from protrusions of greater than 3 mm (patients and laypeople) and 5-mm (clinicians) and retrusions greater than − 8 mm. The overall direction of aesthetic opinion was the same for all the observer groups, but patients were more critical than laypeople.

Part 3: There was little change in perception between T1 and T2. The process of orthognathic treatment does not appear to have any significant effect on patients' perceptions of facial profile attractiveness or the limits of mandibular sagittal deviation at which they would desire surgery.

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Naini, F.B., Donaldson, A.N.A., Cobourne, M.T. and McDonald, F. (2012). Assessing the influence of mandibular prominence on perceived attractiveness in the orthognathic patient, layperson and clinician. *Eur J Orthod* **34**, 738-46..

Naini, F.B., Donaldson, A.N.A., McDonald, F. and Cobourne, M.T. (2012). Assessing the influence of chin prominence on perceived attractiveness in the orthognathic patient, layperson and clinician. *Int J Oral Maxillofac Surg* **41**, 839-46.

Naini, F.B., Donaldson, A.N.A., McDonald, F. and Cobourne, M.T. (2012). Assessing the influence of lower facial profile convexity on perceived attractiveness in the orthognathic patient, layperson and clinician. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology* **114,** 303-11.

Naini, F.B., Donaldson, A.N.A., McDonald, F. and Cobourne, M.T. (2012). Assessing the influence of mandibular and chin point asymmetry on perceived attractiveness in the orthognathic patient, layperson and clinician. *J Oral Maxillofac Surg* **70**, 192-206.

Naini, F.B., Donaldson, A.N.A., McDonald, F. and Cobourne, M.T. (2012). Influence of chin height on perceived attractiveness in the orthognathic patient, layperson and clinician. *Angle Orthod* **82**, 88-95.

Naini, F.B., Donaldson, A.N.A., McDonald, F. and Cobourne, M.T. The influence of combined orthodontic-orthognathic surgical treatment on perceptions of attractiveness: A longitudinal study. *Eur J Orthod* [In press].

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1 Introduction

1.1 Facial beauty and aesthetics

It is almost impossible to clearly and accurately define 'beauty'. Definitions often do not and cannot elucidate the full significance of the concept of beauty. Beauty may be defined as *a combination of qualities that give pleasure to the senses or to the mind* (Naini et al., 2006). The Oxford English Dictionary defines beauty as, 'A combination of qualities, such as shape, colour, or form, which pleases the aesthetic senses, especially the sight.'

The various definitions of beauty and facial beauty each essentially describe the assemblage of graceful features that pleases the eye and mind of an observer, yet the definitions are philosophical, debatable and non-specific. Three variables exist in the definitions of beauty:

The graceful features: The human face is comprised of a number of 'features', e.g. the eyes, nose, lips etc., with a wide array of shapes, sizes, relative positions and colours.

Their assemblage: Which components of which features and in which combinations result in a beautiful face?

The observer: Does each observer see and sense the same beauty?

The number of variables makes it clear that the concept of beauty is difficult to explain with complete clarity.

Aesthetics is the study of beauty and, to a lesser extent, its opposite, the ugly. The 18th century German philosopher Alexander Baumgarten (1714-1762) established aesthetics as a distinct field of philosophy with the publication of his treatise *Aesthetica* (c. 1750) (Baumgarten, republished in 1989). Baumgarten re-coined the term 'aesthetics' to mean 'taste' or 'sense' of beauty, thereby inventing its modern usage; the term 'aesthetics' is derived from the Greek word for sensory perception (*aisthētikos*). Baumgarten defined aesthetics as 'the science of sensual cognition' (Baumgarten, republished in 1989). In effect, Baumgarten separated the concept of beauty from its ancient link related to 'goodness'. Baumgarten defined 'taste' as the ability to judge according to the senses, instead of according to the intellect; such a judgment of taste being based on feelings of pleasure or displeasure.

1.2 The 'eye of the beholder' hypothesis

A longstanding debate revolves round the question of the subjectivity-objectivity of beauty. Beauty may be considered a mystifying quality that some faces have, or may be 'in the eye of the beholder'. Does a face, which one person finds 'beautiful', appeal to another person in the same way? Is the 'beauty' of a face due to some objective quality inherent in the face or is it subjectively determined by each individual with their sensory enjoyment depending on their own ideas, feelings and judgements, which themselves have a direct relation to sensory enjoyment?

The idea that one individual's aesthetic sensibilities may differ from another's has a long tradition. Plato (428-348 BC) alluded to this concept in his *Symposium*, where he described 'Beholding beauty with the eye of the mind' (Plato, republished in 2003). In the 3rd century BC, the Greek poet Theocritus wrote: 'Beauty is not judged objectively, but according to the beholder's estimation' (*The Idylls*) (Theocritus, republished in 1908). Shakespeare re-iterated this view in *Love's Labour's Lost* (1595), saying, 'Beauty is bought by judgement of the eye' (Shakespeare, republished in 1998). In his *Essays Moral and Political* (1742) the philosopher David Hume wrote: 'Beauty, properly speaking, lies…in the sentiment or taste of the reader' (Hume, republished in 1963). In *Jane Eyre* (1847) Charlotte Brontë wrote: 'Most true is it that "beauty is in the eye of the gazer"' (Brontë, republished in 1992). Yet the idea that beauty is according to the observer's estimation became an adage when the writer Margaret Wolfe Hungerford in *Molly Bawn* (1878), famously coined the expression: 'Beauty is in the eye of the beholder' (Hungerford, republished in 1890). In *The Prince of India* (1893), the novelist Lew Wallace repeated the adage as: 'Beauty is altogether in the eye of the beholder' (Wallace, republished in 2005).

The question to consider is one that remains difficult to answer: Is the origin of the human perception of facial beauty dependent on each individual's own sense perception, or is this 'sense' common to all men and women? The above quotations, and their respective philosophical ideology, assume that the 'sense' is subjective to each individual. However, the 18th century philosopher Francis Hutcheson (1694-1746) said, 'Aesthetic judgements are perceptual and take their authority from a sense that is common to all who make them' (Hutcheson, republished in 2005). He went on to say that, 'The origin of our perceptions of beauty and harmony is justly called a 'sense' because it involves no intellectual element, no reflection on principles and causes' (Hutcheson, republished in 2005).

Therefore, if a beautiful face 'pleases universally' then some part of our 'sense' perception must be common to all men and women. After all, when we describe a face as beautiful, we do not merely mean that it pleases us. We are describing the face, not our judgement. We will often point to features of the face to back up our statement. A paradox therefore emerges. Obviously one cannot make a judgement regarding the beauty of a face one has never encountered. Therefore, facial beauty is related to some quality of the observed face, which may be 'universally' accepted. However, each individual's own ideas and feelings, like a conditioned response, also have a direct relationship to their judgement, hence the difference in the extent of rating a face as beautiful depending on the 'eye of the beholder' (Naini et al., 2006).

It is important to bear in mind that any theory that cannot be directly and physically tested remains a philosophy, not a science. Therefore, the answer to the objectivity-subjectivity debate of facial beauty remains unanswered. Perhaps beauty as a concept can be perceived but not fully explained. This debate will no doubt continue.

There is a plethora of evidence in the psychology literature which negates the statement that 'beauty is in the eye of the beholder' and supports the view that judgements of attractiveness are universal (Rubenstein et al., 2002). Yet, most individuals will still admit that judgements of attractiveness differ. There is perhaps an explanation that may have been overlooked: Different individuals will find different types of faces 'very attractive' e.g. one individual may find a certain actor to be extremely beautiful whereas another may find them rather 'average'. The point is that neither will find the actor 'deformed'. It is only with faces within normal limits that arguments occur as to the level of attractiveness, and such judgements may often also be affected by factors other than beauty, e.g. the actor's talent or charisma. In other words, for faces with features that are 'within normal limits', beauty may be, to some extent, 'in the eye of the beholder'. Yet, if a patient with a facial deformity is observed, almost all individuals will agree that the face is deformed and not physically beautiful, i.e. where deformity is concerned, beauty is no longer in the eye of the beholder (Naini, 2011).

1.3 Potential factors involved in the human perception of facial beauty

There are a variety of qualities and characteristics of a human face, which may be responsible for it being perceived as beautiful. These include 'ideal' proportions, bilateral symmetry, averageness, youthfulness and sexual dimorphism. Hereditary factors and cultural influences also play an important part. Any or all may have an effect on the human conception of the beautiful, but none fully explains *why* one face is seen as beautiful and another as unattractive. Nevertheless, a number of explanations and hypotheses have been used in the attempt to explain why a face may be perceived as beautiful and another as unattractive.

1.3.1 'Ideal' proportions

The concept that 'ideal' proportions are the secret of beauty is perhaps the oldest idea regarding the nature of beauty (Naini, 2011). The ancient Egyptians had a great interest in art and beauty. The famous painted limestone figure of Queen Nefertiti (c. 1350 BC) with her harmonious facial proportions and symmetry is an example of how the Egyptians immortalized the beauty of their kings and queens by depicting them, perhaps unrealistically, with 'ideal' facial proportions (Naini, 2011). In fact the name Nefertiti literally means the 'Beautiful One'. Lesser dignitaries were not so honoured and had more realistic depictions in art and sculpture. The Egyptian proportional canons, however, used grids with meshes of equal sized squares. This was to change with the age of Greek sculpture, which rather than featuring fixed units, described proportion between the parts of the whole human figure.

In the course of his travels the Greek mathematician Pythagoras (6^{th} century BC) is extremely likely to have come into contact with the mathematical treatises of the Egyptians. He postulated that beauty could be explained through mathematical laws and laws of proportion. He proposed an explanation of beauty through a significant finding, that plucking taut strings of proportionately different lengths produces harmonious notes. The difference in the proportionate lengths of the strings followed mathematical laws, and hence his explanation of laws of proportion. The term Pythagoras used to describe beauty was 'cosmos' as he felt that beauty was part of the mathematical order of the universe, hence the origin of the word 'cosmetic'.

Throughout the ages, painters and sculptors have attempted to establish ideal proportions for the human form, however, possibly the most famous of all axioms about 'ideal' proportions is that of the golden proportion (Ricketts, 1982).

1.3.1.1 Golden proportion

This is a geometrical proportion in which a line AB is divided at a point C in such a way that AB/AC = AC/CB. That is, the ratio of the shorter section to the longer section of the line is equal to the ratio of the longer section to the whole line. This gives AC/AB the value 0.618, termed the golden number. The point at which the line is divided is known as the golden section and is represented by the symbol Φ (Phi) derived from the name of the Greek sculptor Phidias. This proportion has classically been described as pleasing to the eye, the emphasis being upon the proportion of the parts to the whole. The prominent mathematician Euclid (c. 325-265 BC) described this in his treatise *The Elements*. In his edition of Euclid's Elements, the mathematician Luca Pacioli (1509) re-named the golden proportion the 'Divine Proportion' as he felt the concept could not be fully explained, and published a treatise entitled *De Divina Proportione* (*On Divine Proportion*) for which Leonardo da Vinci drew figures of symmetrical and proportionate faces and bodies (Naini, 2011). Maestlin gave the first known calculation of the golden proportion as a decimal in a letter to his former pupil, the famous astronomer Johannes Kepler in 1597 (Herz-Fischler, 1998).

1.3.1.2 Fibonacci numbers

Another often quoted concept, which some authorities have argued gives some credence to the golden proportion, is the Fibonacci sequence (Ricketts, 1982). The distinguished mathematician Leonardo of Pisa (1170-1240), also known as Leonardo Fibonacci, devised a number sequence in which each number is the sum of the two preceding numbers, i.e. 1, 1, 2, 3, 5, 8, 13, 21, 34, 55 etc. In the 19th century the mathematician

Edouard Lucas coined the term Fibonacci sequence, and scientists began to discover the numbers in nature, such as in the spirals of sunflower heads, the logarithmic spiral in snail shells and in animal horns. As the numbers increase in magnitude, the ratio between succeeding numbers approaches the golden proportion.

Attempts have been made to apply the concept of the golden proportion to dental aesthetics. In terms of smile aesthetics the golden proportion may be applied to the *apparent* mesiodistal width of the anterior teeth when viewed from the frontal aspect. This can be useful in designing the relative width of teeth in a beautiful smile (Snow, 1999), though the evidence is certainly not conclusive (Naini, 2011).

There have also been attempts to correlate ideal facial proportions with the golden proportion (Ricketts, 1982). However, the faces of professional models have not been found to always fit the golden proportion (Moss et al., 1995), and a study looking at the aesthetic improvement of patients undergoing orthognathic surgery found that while most subjects were considered more aesthetic after treatment than before, the proportions were equally likely to move away from or toward the golden proportion (Baker and Woods, 2001). Therefore, more evidence is required to substantiate the true significance of this concept in the clinical assessment of facial aesthetics.

1.3.1.3 Canons of proportion

The idealization of human proportions was a major preoccupation of Greek sculptors. One of the most famous, Polycleitos (late 5th century BC), wrote the *Canon*, a theoretical work that discussed ideal mathematical proportions for the parts of the human body. Roman copies of one of his most famous statues, the ‘Doryphorus’ (‘Spear Bearer’), still exist (Figure 3.1). This statue is itself often referred to as the ‘Canon’ because it embodies Polycleitos’ views on the correct proportions of the ‘ideal’ male form. In the 2nd century AD the prominent Greek physician and philosopher Galen said, ‘Beauty does not lie in the individual parts, but in the harmonious proportion of all the parts to all the others, as is stated in the Canon of Polycleitus.’

Phidias (c. 490-430 BC), a contemporary of Polycleitos, was an Athenian famous as one of the most outstanding of all sculptors. He directed the construction and design of the Parthenon, the chief temple of the Greek goddess Athena on the hill of the Acropolis at Athens. The Parthenon itself, and the statues contained within it, were said to conform to ‘ideal’ proportions, with Phidias *possibly* incorporating the golden proportion into the architectural design (Green, 1995). It is said of Phidias that he alone had seen the exact image of the gods, and that he revealed it to man. In ancient Greece, sculpture of the human form was used to represent the many gods. As these sculptures were constructed with ideal proportions, the belief arose that the better ‘mortals’ looked, the more godlike they were.

The Roman architect Marcus Vitruvius Pollio (1^{st} century BC) is well known for describing the facial trisection. He referred to the ‘symmetrical harmony’ of the ‘ideal’ human body and compared this to ‘perfect buildings’ (Howe, 1999). Vitruvian concepts of proportion and symmetry were essentially Hellenistic, being based on those of the Greeks. Vitruvius’ influence continued through his ten-volume work *De architectura*. Leonardo da Vinci later immortalised aspects of Vitruvian concepts regarding the proportions and symmetry of the human body.

Leonardo da Vinci (1452-1519) was a Renaissance genius who excelled as a painter and sculptor, in addition to architecture, engineering, human physiology and anatomy. He defined proportion as the ratio between the respective parts and the whole (Naini, 2011). His notebooks reveal his quest for the ideal facial proportions. He produced studies of the proportions of the human head, a table of possible nose types, and combinations of various forms of foreheads, chins, noses and mouths. The figure of Vitruvian man (Figure 3.2), which Leonardo based on guidelines described by Vitruvius, represents 'ideal' male proportions based on man's navel as the centre of a circle enclosing man with outstretched arms. This shows the importance of proportions in the human form. The distance from the hairline to the inferior aspect of the chin (soft tissue menton) is one-tenth of a man's height. The distance from the top of the head to soft tissue menton is one-eighth of a man's height. The clinical implication is that when planning treatment changes, for example to the vertical face height of a patient, it can be misleading to base the intended result on absolute numeric values based on population norms. People are not necessarily 'average'. It is prudent, therefore, to plan treatment bearing in mind the patient's standing height and stature, and aim to correct the individual's proportions (see chapter 3).

Albrecht Dürer (1471-1528), generally acknowledged as the greatest German Renaissance artist, maintained the importance of studying facial proportions. His *Treatise on Human Proportions*, published posthumously in 1528, contained illustrations depicting perfect proportions of the aesthetically 'ideal' human face and figure. Dürer maintained that disproportionate human faces were unattractive, whereas proportionate features were acceptable if not always beautiful (Naini, 2011). Therefore clinicians can make the assessment of facial aesthetics more objective by diagnosing and helping to correct facial disproportions.

1.3.2 Bilateral symmetry

Facial symmetry also seems to be an important aspect of facial beauty, although mild asymmetry is essentially normal (Grammer and Thornhill, 1994). In fact, image manipulation techniques used to create perfectly symmetrical facial images of the same individual have found the original to be more attractive than the created perfectly symmetrical image, i.e. 'normal' asymmetry is preferred to perfect bilateral facial symmetry (Langlois et al., 1994). Rhodes et al. (1999) found that symmetry was an important factor in facial attractiveness, but 'averageness' appears to be more important. Rubenstein et al. (2002) concurred, that no matter how symmetrical a face, 'averageness is the only characteristic discovered to date that is both necessary and sufficient to ensure facial attractiveness…without a facial configuration close to the average of the population, a face will not be attractive.'

1.3.3 Averageness

Studies in the late 1800s by Sir Francis Galton (1822-1911), the cousin of Charles Darwin, accidentally found evidence to support what came to be known as the 'averageness hypothesis' of facial beauty (Galton, 1879). Galton was in fact trying to find *typical faces*, e.g. the typical 'criminal face'. He created composite faces by overlying multiple images of prisoners and criminals or a variety of other subjects onto a photographic plate. Not only was Galton's original theory of 'typical faces' incorrect, but he found that the composite faces became more attractive than any of the individual faces. Further research has verified that composite facial photographs gain higher attractiveness ratings than their individual facial photographs (Langlois and Roggman, 1990). However, Perrett et al. (1994) have shown that attractive composite faces were made more attractive by exaggerating the shape differences from the sample mean. Therefore, an average face shape is attractive but may not be optimally attractive.

The term 'averageness' implies proximity to the population mean, i.e. the use of normative data from population samples is often used by orthodontists and facial aesthetic surgeons, in the form of cephalometric and anthropometric data, for diagnosis and treatment planning.

1.3.3.1 Koinophilia

The term koinophilia ('love of the average'), derived from the Greek, *koinos*, meaning 'common' or 'average,' and *philos*, meaning 'love,' means when seeking a mate, sexual creatures prefer that mate to have a preponderance of average or common physical features, i.e. not to exhibit any unusual or peculiar features. The argument is that natural selection leads to beneficial physical features becoming increasingly more common with each generation, while the disadvantageous features become increasingly rare. Thus, sexual creatures wishing to mate with a 'fit' partner (in evolutionary terms, 'fit' means 'best able to adapt to the environment,' and thereby have a better chance of bearing healthy offspring), would be expected to avoid individuals with unusual features, while being attracted to those displaying 'average' features. This mating strategy was first referred to as koinophilia by the biologist Johan Koeslag (Koeslag, 1990). In humans, this concept may be linked to the 'averageness hypothesis' (Langlois et al., 1994; Langlois and Roggman, 1990).

1.3.4 Facial neoteny

The term neoteny refers to the retention of juvenile features in the adult, alternatively termed paedomorphosis. The retention of neotenous facial features in adult humans is also termed babyfaceness. Childlike facial features, such as relatively larger eyes, small nose, full lips and a round face have been found to correlate with attractiveness, particularly for women. This may be due to the natural human tendency to nurture a baby (Zebrowitz, 1993). Nevertheless, there is also evidence that women find a combination of masculine and babyface (more feminine) features in men attractive, and that their preference for more masculine features increases during the menstruation phase most likely to result in successful conception (Little et al., 2002).

1.3.5 Sexual dimorphism (secondary sexual characteristics)

Male and female faces diverge at puberty (Rhodes, 2006). In males, testosterone stimulates the growth of the jaws, cheekbones, brow ridges and facial hair. In females, growth of these regions is inhibited by oestrogen, which may also increase lip size

(Thornhill and Møller, 1997). As sexual dimorphism increases at puberty, sexually dimorphic traits signal sexual maturity and reproductive potential (Rhodes, 2006). Gillian Rhodes, one of the leading researchers in the field of psychology in relation to facial attractiveness, explains that current evidence suggests that femininity is attractive in female faces and is preferred to averageness; masculinity is also attractive in male faces, though the effect is smaller than for female faces. She concluded that the 'evolutionary psychology of facial attractiveness is just beginning' (Rhodes, 2006).

1.3.6 Heredity

The human perception of facial beauty may have its foundation in our heredity, environment, or perhaps both. Langlois et al. (1987) found that infants as young as three months of age have the ability to distinguish between attractive and unattractive faces, showing signs of preference for the former. It is unlikely that by three-months of age an infant will have been subjected to or responded to any cultural or environmental influences, therefore this is evidence to support a genetic theory. The evolutionary basis is that facial beauty, including facial symmetry and secondary sexual characteristics, is a requirement for sexual selection, leading to improved chances for successful reproduction (Jones, 1999).

1.3.7 Cultural influences

In *The Descent of Man* (1871), Charles Darwin (1809-1882) observed and described large cultural differences in the beautification practices of peoples around the world (Darwin, republished in 2003). There are many such examples of cultural factors, which undoubtedly have some considerable influence on our perception of beauty.

A study by Martin (1964) found that both white and black American males preferred black female faces with Caucasian features, whereas black African men showed a preference for black female faces with Negroid features. This lends evidence to support environmental/cultural reasons for the human perception of facial beauty. However, Perrett et al. (1994) found that both Caucasian and Japanese men and women ranked female faces as most attractive when youthful facial features, such as large eyes, high cheekbones and a narrow jaw were evident. Aesthetic judgments therefore seemed to be similar across different cultural backgrounds. A meta-analysis undertaken by Langlois et al. (2000) seems to confirm that there is cross-cultural agreement regarding facial attractiveness. However, the influence of an international media cannot be discounted.

1.4 Historical and philosophical perspectives on facial beauty

Throughout history, each age seems to have provided somewhat different explanations for the concept of human beauty and its proposed merits. The opinions of some individuals have echoed one another, whereas others have vehemently disagreed (Naini, 2011).

Plato (429-347 BC) described beauty as goodness, but felt that physical beauty was inferior to spiritual beauty, i.e. he described physical and metaphysical beauty (*Symposium*) (Plato, republished in 2003). In *Phaedo*, Plato informs us that Socrates (469-399 BC) felt that the human body and physical beauty was an 'impediment…distracting us from getting a glimpse of the truth', and that the beauty of the soul was far superior (Plato, republished in 1999). Socrates advised, 'let us seek the *true* beauty, not asking whether a face is beautiful…for such things are always in flux'; he continued: 'grant that I may become beautiful *within*' (Plato, republished in 1999). The ideas of Socrates proved unpopular, to say the least, with the Greek masses love of physical beauty.

Aristotle (384-322 BC) did not develop Plato's theory of 'beauty as goodness'. In fact, he distinguished between them, for '*goodness implied conduct as its subject, whereas* *beauty is found in motionless objects*'. In his *Metaphysics*, Aristotle gave the following definition of beauty, '*The chief forms of beauty are order and symmetry and definiteness*'; this is the idea of beauty as proportion (Aristotle, republished in 2004). Aristotle felt that beauty was a purely physical phenomenon and emphasized proportionality as the basis of human beauty, i.e. he denied the existence of metaphysical beauty.

For the Greeks the concept of physical beauty was linked to their Gods, i.e. 'ideal' proportions and symmetry provided physical beauty to man, but this 'beauty' brought man closer to resembling the Gods.

Saint Thomas Aquinas (1225-1274) separated physical and metaphysical beauty, but believed that both existed (*Summa Theologiae*) (Aquinas, republished in 2006): 'Beauty of body consists in shapely limbs and features…beauty of spirit consists in conversations and actions that are well-formed and suffused with intelligence'.

Aquinas believed spiritual beauty to be of a far 'higher order' than physical beauty. Despite Aquinas clearly separating spiritual and physical beauty, to the unenlightened medieval minds physical beauty and morality were inextricably linked, i.e. physical beauty was thought to be linked to goodness and physical ugliness to moral degradation.

The separation of the concept of beauty into a secular, nonspiritual, 'earthly' concept began with the Renaissance in the 14th-16th centuries.

The writer Michel de Montaigne (1533-1592) and one of the most significant figures of the European intellectual movement of the 17th and 18th centuries known as the Enlightenment, the philosopher Voltaire (1694-1778), described human beauty as culturally determined, with no objective existence, i.e. beauty is in the 'culture' of the beholder. Montaigne wrote of beauty, 'We imagine its form to suit our fancy…..In Peru, the biggest ears are the fairest, and they stretch them artificially……Elsewhere there are nations that blacken their teeth with great care, and scorn to see white teeth' (Montaigne, republished in 1958).

The Scottish philosopher David Hume (1711-1776) felt that beauty was not only culturally determined but also individually subjective, i.e. the idea that 'beauty is in the eye of the beholder'. In his essay '*Of the Standard of Taste*' (1757), Hume wrote, 'Beauty is no quality in things themselves: It exists merely in the mind which contemplates them; and each mind perceives a different beauty. One person may even perceive deformity, where another is sensible of beauty; and every individual ought to acquiesce in his own sentiment, without pretending to regulate those of others' (Hume, republished in 1995).

Hume felt that beauty was a socially constructed phenomenon. In '*The Sceptic*' he wrote, 'Beauty is not a quality of the circle…it is only the effect, which that figure produces upon a mind, whose particular fabric or structure renders it susceptible of such sentiments' (Hume, republished in 1963). In '*A Treatise on Human Nature*' (1738) Hume wrote, 'Beauty is such an order and construction of parts, as…to give a pleasure and satisfaction to the soul. This is the distinguishing character of beauty, and forms all the difference betwixt it and deformity, whose natural tendency is to produce uneasiness. Pleasure and pain, therefore, are not only necessary attendants of beauty and deformity, but constitute their very essence' (Hume, republished in 1961).

Immanuel Kant (1724-1804), in his *Critique of Judgement* (1790), rejected Hume and returned to Plato, 'The beautiful is the symbol of the morally good' (Kant, republished in 1978). Tolstoy, in *The Kreutzer Sonata* (1890), opposed Kant, writing: 'It is amazing how complete is the delusion that beauty is goodness' (Tolstoy, republished in 1924). Kant also felt that 'the beautiful is that which pleases universally without a concept' (Kant, republished in 1978). Friedrich Schiller (1759-1805) was a follower of Kant; he felt that beauty provided pleasure without practical advantage (Schiller, republished in 1983). Philosopher's and their opinions continued to wax and wane.

In the *Descent of Man* (1871), Charles Darwin described the cultural deviations in the standards of human beauty, writing, 'It is certainly not true that there is in the mind of man any universal standard of beauty with respect to the human body' (Darwin, republished in 2003).

Darwin believed that the perception of beauty is a feeling natural to man and to animals, and consequently to the ancestors of man. He also felt that beauty had an array of diverse conceptions and could not be easily explained. The evolutionary basis is that facial beauty makes a particularly significant contribution to sexual selection, leading to improved opportunity for reproduction.

In the 19^{th} century, the writer and thinker Ralph Waldo Emerson (1803-1882) wrote two essays entitled 'Beauty,' in *Nature* (1836) (Emerson, 1971a) and in *The Conduct of Life* (1860) (Emerson, 1971b). In the former essay, Emerson explains that true beauty is inherent in Nature and the 'simple perception of natural forms is a delight.' Yet he feels that the appreciation of such beauty requires 'virtue' and 'intellect' on the part of the observer. He writes, 'No reason can be asked or given why the soul seeks beauty. Beauty, in its largest and profoundest sense, is one expression of the universe' (Emerson, 1971a). In the latter essay, Emerson writes, 'Beauty is the form under which the intellect prefers to study the world. All privilege is that of beauty; for there are many beauties; as, of general nature, of the human face and form, of manners, of brain, or method, moral beauty, or beauty of the soul.' In terms of physical beauty, he writes: 'Any fixedness, heaping, or concentration on one feature, - a long nose, a sharp chin, a hump-back, - is the reverse of the flowing, and therefore deformed (Emerson, 1971b).

In the 20^{th} century, in a published lecture entitled *Truth and Beauty* (1987), the distinguished Indian-born American astrophysicist and Nobel laureate Subrahmanyan

Chandrasekhar (1910-1995) explained that the quest of the arts and sciences is after 'the same elusive quality: beauty' (Chandrasekhar, 1987). He went on to define beauty as 'that to which the human mind responds at its deepest and most profound (Chandrasekhar, 1987).

1.5 Importance of facial beauty and attractiveness

The significance of facial beauty is immense, with psychological, sociological, philosophical, moral and scientific conceptions, often intertwined. Beauty is a multidimensional concept that undoubtedly has a strong influence on human life. In western literature beauty has been described as everything from a 'social necessity' to a 'gift from God' (Aristotle) (Lloyd, 1968). The poet John Milton refers to the 'strange power' of beauty, describing beauty as 'Nature's brag' (Milton, republished in 1942). The French philosopher Blaise Pascal commented, 'Cleopatra's nose, had it been shorter, the whole face of the world would have been changed!' (Pascal, 1966). From Homer's Helen of Troy, who the poet Christopher Marlowe described as having the 'face that launched a thousand ships' (Marlowe, republished in 1995), to Queen Nefertiti whose name literally means the 'Beautiful One', to modern day models and actors, facial beauty has perhaps always been the most valued aspect of human beauty.

Facial beauty is an important factor in an individual's self image and in relation to outsider's perceptions.

1.5.1 Self image and negative self-perception

A person's own perception of their facial appearance and any associated deformity is of great importance (Cash and Pruzinsky, 1990). Of course, there is considerable individual variation in people's abilities to adapt to their facial deformity, whatever the severity.

Some individuals remain comparatively unaffected, while others may have significant difficulties, which affect their quality of life.

1.5.2 Outsider's perceptions

The effects of outsider's perceptions may be categorized as follows:

1.5.2.1 'Social disability'

It has been argued that facial deformity may be a 'social disability', as its impact is not only on the individual affected, but is noticed by and reacted to by others (Macgregor, 1979). Attractive children tend to be perceived more positively by their parents (Langlois et al., 1995), by teachers who perceive more attractive children as being more intelligent (Clifford and Walster, 1973), and in professional life where less attractive adults are perceived as having fewer qualifications and less potential for employment success (Hosoda et al., 2003). Although an individual's facial appearance contributes to the opinions other people form of them, obviously these opinions may well change as interpersonal relationships form. Nevertheless, an individual's first impression on others may well affect their own self-esteem and quality of life (Macgregor, 1979).

1.5.2.2 Stereotyping

It is suggested that people tend to stereotype others based on their facial appearance (Langlois et al., 2000). For example, individuals with significant Class II malocclusions and mandibular retrognathia/retrogenia may be seen as weak and possibly idle, whereas individuals with significant Class III malocclusions and mandibular prognathism may be seen as aggressive personality types.

1.5.2.3 Teasing

Children in the school environment can be unsympathetic and hostile to those with visible differences, with teasing and bullying being everyday occurrences. The frequency of teasing directed at those with dentofacial differences is significant (Shaw et al., 1980).

1.5.3 Severity of deformity

The psychological distress caused by a facial deformity is not proportional to its severity. Research seems to indicate that facial deformities of a mild to moderate nature actually cause patient's greater psychological distress than severe facial deformities (Macgregor, 1970). This is thought to be because other people's reactions towards milder deformities are more unpredictable whereas more severe deformities tend to evoke more consistent reactions, albeit negative, allowing the patient to develop better coping strategies. The variability in people's reactions to milder facial deformities also results in considerable patient distress. It is important to note that the majority of patients seeking orthodontic treatment or orthognathic surgery fit into the mild/moderate category in terms of facial deformity, as opposed to craniofacial malformation syndromes or severe facial trauma/disease (Naini et al., 2006).

1.6 Facial attractiveness research

1.6.1 Historical perspectives

The scientific studies of the possible proposed explanations for facial beauty in terms of 'ideal' proportions, bilateral symmetry, averageness, babyfaceness and sexual dimorphism have been described above.

The other area of scientific research in the understanding of facial beauty is termed facial attractiveness research, i.e. the scientific study of facial beauty and physical attractiveness. The purpose of such research is to find quantifiable evidence for the attractiveness of various facial parameters using contemporary layperson and patient population survey preferences rather than subjective interpretations or observations made by artists or clinicians. The results of such studies are presented in section 1.6.2.

It is, however, important to note that the first scientific study of attractiveness was undertaken in England by the artist William Hogarth (1697-1764), published in a work entitled *The Analysis of Beauty* (1753). Hogarth drew the image of a woman's corset, and then proceeded to create variations of the same image while altering a certain aspect of the corset in each image. He subsequently invited members of the public to choose their favourite image. The experiment was repeated using images of various objects. The originality of the experiment was that each set of images varied only in one respect and the variation was graded. Hogarth felt that this would allow him to know *why* one image was preferred to another. Hogarth's conclusion was that the most beautiful images were composed of gently curving lines. This led to Hogarth's concept of the 'Line of Beauty', a term used to describe an S-shaped curved line, or 'serpentine line,' appearing within an object, as the boundary line of an object, or as a virtual boundary line formed by the composition of several objects (Naini, 2010). According to this theory, S-shaped curved lines signify liveliness and activity and excite the attention of the observer as contrasted with straight lines, parallel lines, or right-angled intersecting lines which signify inanimate, unattractive objects.

It is clear that the serpentine line cannot be the only explanation of beauty, as was quickly pointed out by Hogarth's critic, the actor and playwright David Garrick (1717-1779). Garrick explained that a shape that is attractive in one object may be rather unattractive in another, e.g. a gentle curve on the side of a vase is not so attractive in a protruding belly. There is simply no one factor that creates beauty. Yet the experimental method chosen by Hogarth seems to be original, perhaps making him the 'father' of the modern attractiveness research design (Naini, 2011).

1.6.2 Modern facial attractiveness research studies

Research in the area of perceptions of facial attractiveness has been enormously productive in the psychology literature over the past two decades (Rhodes, 2006). Twenty years ago, standards of facial beauty were thought to be idiosyncratic and arbitrary, the products of culture and the media. However, instead of being idiosyncratic, many standards of facial attractiveness have been found to be highly consistent across individuals and diverse cultures. Instead of being arbitrary, they appear to reflect the operation of basic perceptual and cognitive mechanisms and the selection pressures operating during human evolutionary history. Nevertheless, individual learning and the role of the media cannot be discounted (Rhodes, 2006; Rubenstein et al., 2002; Zaidel and Cohen, 2005).

1.6.2.1 Importance of attractiveness research studies

The results of attractiveness perception studies may be important in the understanding of human psychology. Additionally, they are also important in the clinical practice of orthodontists and surgeons dealing with patients with dentofacial and craniofacial deformities. The results of such studies permit a greater understanding of patient motivations for treatment that will alter their facial appearance. What is a severe problem to one patient may be perceived as a minor problem by another patient or a clinician, and vice versa (Bell et al., 1985). In addition, the results of such studies shed light on threshold values of desire for surgical correction in relation to different dentofacial deformities.

Each facial parameter, such as chin prominence, will have an ‘average’ value or ‘norm’ for a given population, which is specific for age, gender and ethnicity. Each of these ‘norms’ will also have a range of variability, with the existence of a facial deformity often resulting from a significant deviation of one or more facial parameters from the accepted norm for a population. The results of attractiveness perception studies may provide quantitative evidence for the point at which the deviation of a facial parameter moves from the limits of the acceptable range of variability into being perceived as a facial deformity.

The magnitude of the deviation, whether it is due to an underlying dento-skeletal discrepancy, the overlying facial soft tissues or a combination of the two, is an important factor in decision-making when jaw surgery may be required. If the magnitude of the discrepancy of a facial parameter is great (for example significant chin prominence) then the treatment planning decision may be relatively straightforward. However, there are a significant number of patients who are regarded as ‘borderline’ in terms of need for surgical treatment. In such patients, the decision making process may be transferred from subjective clinical judgement to objective, evidence-based guidance based on data from studies investigating perceptions of facial attractiveness. For example, if the relative position or size of a facial parameter, such as chin prominence, is being assessed, it may be found that a large percentage of observers find that greater than *x* mm of chin prominence from the true facial vertical line is regarded as unattractive and requiring surgical correction. This would provide objective evidence to guide clinicians when planning treatment.

A review of the facial attractiveness studies most pertinent to this thesis is presented in this section. The Medline, Embase, Google Scholar and Scopus databases were searched to identify studies using the following terms: asymmetry, attractiveness, chin, convexity, craniofacial height, facial profile, mandible, perceived attractiveness, perception, profile convexity, prominence, prognathia, prognathic, protrusion, retrognathia, retrognathic, retrusion, vertical facial proportions. The Boolean operators ‘AND’ and ‘NOT’ were used to focus the searches. The reference sections of identified articles were also searched. A summary of the most relevant studies is presented in table 1.1.

Table 1.1.1 Summary of facial attractiveness studies most pertinent to this thesis

Study	Facial parameter	Design	Images	Observers	Results
Arpino et al., 1998	Facial profile: sagittal mandibular position	Feature animated between two extremes; 'zone of acceptability' established by pressing computer mouse when the changing feature became acceptable and releasing the button when the image was no longer acceptable. In a separate task, asked to indicate most pleasing position.	Profile images of 11 patients scheduled for orthognathic surgery limited to the mandible (i.e., set-back or advancement), *animated for continuous change* with customized morphing software	• Presurgical orthognathic patient (n=11) • Patient's significant other • Orthodontists (n=3) • Oral surgeons (n=3)	• All groups had similar preferences. • Orthognathic patients had the lowest tolerance for deviation from the preferred image.
Cochrane et al., 1999	Facial profile: comparison of Class I, II	Ranking in order of attractiveness	Manipulated photographs of 4 Class I profiles (2M and	• Orthodontists, • Maxillofacial surgeons, • Dental	• Class II profiles are less attractive than Class III profiles. • Female assessors were more likely to rank the Class I profile as most attractive

Study	Facial parameter	Design	Images	Observers	Results
	and III facial profile pattern		2F); produced Class II, III and ‘long’ face profiles	students, • Laypeople	
Coleman et al., 2007	Facial profile: influence of chin prominence on preferred lip position	Using the computer keypad, each observer moved the lips to the positions they perceived as most attractive.	5 ‘male’ and 5 ‘female’ silhouette profiles differing only in the degree of mandibular retrognathism or prognathism (-25, -18, -11, -4, and +3 degrees facial contour angles) were created. Using a computer animation program, the evaluators moved the upper and lower lips independently into the positions they	• Patients: white male (n=20) and female (n=20) adolescent orthodontic patients • Parents of patients (n=20M; 20F) • Orthodontists (n=20M; 20F)	• In general, no differences in preferred lip position were found between the -11 and -4 degrees profiles or between the -18 and +3 degrees profiles, but preferences for each of the 3 profile groupings (-11 degrees and -4 degrees, -18 degrees and +3 degrees, and -25 degrees) were different. • Fuller lip positions were preferred for the more extreme retrognathic and prognathic profiles, • More retrusive lip positions were preferred for the more average profiles. • No differences were found among the 3 evaluator groups or between male and female evaluators.

Study	Facial parameter	Design	Images	Observers	Results
			deemed to be the most aesthetic for each profile.		
Czarnecki et al., 1993	Facial profile: Nose, lips, and chin relationships, changes in facial angle and angle of convexity.	Ranking on the basis of most preferred to least preferred	Constructed androgynous facial silhouettes	• Professionals (n=545)	• Class II profiles are less attractive than Class III profiles. • A straighter profile was preferred in males, in comparison with a slightly convex profile in females. • The most unfavourable features were a severely recessive chin or a severely convex face. • More lip protrusion was found acceptable for both male and female faces when either a prominent nose or a prominent chin was present.
De Smit and Dermaut, 1984	Facial profile: Sassouni profile types	Ranking	27 profile silhouettes	• Dental students (n=69M, 49F) • Laypeople (n=91M, 40F)	• Vertical proportions are more important than sagittal. • Reduced LAFH more acceptable than increased LAFH.
Foster, 1973	Facial profile: Lip retrusion and protrusion	Each observer selected 1 of the 7 profiles as most attractive for each category (child, adult, male, female).	Profile silhouette: sagittal lip position altered in 2 mm increments, from – 6 to + 6	• Orthodontists (n=30) • Dentists (n=30) • Art students (n=30) • White	• Diversified groups seem to share a common aesthetic standard for lip protrusion, in most cases within 1-2 mm. • All groups were consistent in assigning ‘fuller’ lips for younger ages • All groups preferred at least 3 mm ‘fuller’ lips for adult females; except orthodontist, who saw ‘full’

Study	Facial parameter	Design	Images	Observers	Results
			mm	laypersons (n=30) • Black laypersons (n=30) • Chinese laypersons (n=30)	lips at 1.4 mm. • All groups preferred adult male lips to be more behind E and H lines than 'ideal' values; adult females were closer to, but still further behind than 'ideal' values.
Hall et al., 2000	Facial profile	Rating on a visual analogue scale (VAS) of 0 to 100	Profile silhouettes of 30 African American and 30 white patients, ranging in age from 7 to 17 years	• White orthodontists (n=20) • African American orthodontists (n=18) • White laypersons (n=20) • African American laypersons (n=20)	• 6 cephalometric variables were significant in attractiveness perception: Z-angle, skeletal convexity at A-point, upper lip prominence, lower lip prominence, nasomental angle, and mentolabial sulcus. • All raters preferred the African American sample to have a greater profile convexity than they preferred for the white sample. • The raters preferred the African American sample with upper and lower lips that were more prominent compared with the white sample. However, only the choice of the African American orthodontists for the African American sample was significantly different for this parameter. • The white orthodontists gave the highest mean scores for the profile chosen, whereas the African American laypersons gave the lowest scores.
Hönn et al.,	Facial profile	Seven patients	7 patients with	• Laypersons	• The straight average face was perceived as most

Study	Facial parameter	Design	Images	Observers	Results
2005	convexity: Class II and III profiles	with orthognathic profiles, Onyx Ceph software used to modify their profile lines to obtain 21 retrognathic and 21 prognathic images. Overall 49 images used.	skeletal Class I, (profile lines (of Schwarz) were modified to reflect three different Class II and three different Class III profile variants	(n=130) • Dentists (n=126)	attractive by laypersons and dentists alike, followed by the mildest variant of the retrognathic face. • Dentists differentiated more clearly by degree of skeletal malocclusion than did laypersons. • Both groups alike perceived the extreme variant of the prognathic and retrognathic profile lines as the least attractive. • Grouping the subjects by gender yielded only minor differences in perception. • The straight average face is perceived as most attractive by representative German populations today.
Ioi et al., 2007	Facial profile convexity: but assessed sagittal chin position only as the variable	Rating for attractiveness	Profile silhouettes of average male and female Japanese profiles were constructed (30 males and females with normal occlusions) - Chin positions were protruded or retruded by 2, 4, 6, 8 and 10	• Orthodontists (n=41) • Dental students (n=50)	• For males, both the orthodontists and dental students chose the average profile as the most-favoured profile. • For females, both the orthodontists and dental students chose a slightly more retruded chin position as the most-favoured profile. • Japanese raters tended to choose Class II profiles as more acceptable than Class III profiles for both males and females. • Findings suggest that Japanese patients with Class III profiles tend to seek surgical orthodontic treatment more often.

Study	Facial parameter	Design	Images	Observers	Results
			degrees from the average profile		
Johnston et al., 2005a	Facial profile: Mandibular prominence	• Rating on a numerical attractiveness scale of 1 to 10; • Would you seek treatment if own appearance? • Rating own 'smile' • Rating importance of attractive 'smile'	Profile silhouette: images cropped, i.e. half forehead, no neck.	1st year university social science students (n=102: 28 M; 74 F)	• Profile with the normal SNB angle of 78 degrees was rated as the most attractive. • Attractiveness scores reduced as the mandibular profile diverged from the normal SNB value. The +5 degree profile (SNB = 83 degrees) was rated as significantly more attractive than the -5 degree profile (SNB = 73 degrees). • No other significant differences between the scores for Class II and Class III profile pairs of equal severity were found. • At 10 degrees below the normal SNB (Class II), 74 per cent of the sample would elect to have treatment. • At 10 degrees above the normal SNB (Class III), 78 per cent would elect to have treatment.
Johnston et al., 2005b	Facial profile: Lower anterior face height (LAFH)	• Rating on a numerical attractiveness scale of 1 to 10; • Would you seek treatment if own appearance? • Rating own 'smile'	Profile silhouette – modified to reflect a change in LAFH of 4 SDs in both directions. Images cropped, i.e. half forehead, no	1st year university social science students (n=92: 8 M; 84 F)	• The most attractive profile was the one with the ideal face height ratio of 55%. • Increasing LAFH had a greater negative effect on the attractiveness than a similar reduction in LAFH. • A 4 SD reduction in LAFH would prompt 25% of the judges to seek treatment. • A 4 SD increase in LAFH would prompt nearly half the judges to seek treatment.

Study	Facial parameter	Design	Images	Observers	Results
		• Rating importance of attractive 'smile'	neck.		
Kerr and O'Donnell, 1990	Full face and profile	Rating for attractiveness	Full-face and profile photographic transparencies of 60 subjects (30M, 30F) divided equally among Class I, Class II Division 1, and Class III malocclusions, before and after orthodontic treatment	• Orthodontists • Dental students • Art students • Parents of children undergoing treatment	• Facial profiles of subjects with Class I malocclusion more attractive than those with Class II or Class III profiles • Art student and parent panels were less critical in their appraisal of facial attractiveness, • Art student and parent panels were less sensitive to the changes brought about by orthodontic treatment than the orthodontist and dental student panels
Knight and Keith, 2005	Facial profile: • ANB difference • LAFH	Ranking in order of attractiveness	Photographs of 30M and 30F Caucasian subjects	• Clinicians (n=6) • Non-clinician (n=6)	• Sagittal discrepancies measured by soft tissue ANB showed minimal correlation with facial attractiveness. However, a trend emerged suggesting that in faces where ANB varies widely from 5 degrees, the face is considered less attractive. • The LAFH percentage showed minimal correlation with facial attractiveness. However, a trend

Study	Facial parameter	Design	Images	Observers	Results
					suggested that greater LAFH percentages are considered less attractive in female faces, while in males the opposite trend was seen.
Kuroda et al., 2009	Facial profile: Sagittal mandibular prominence	Ranking in order of attractiveness	9 morphed profile images with Point B and menton protruded or retruded	• Laypeople (n=262; 121M; 141F); Japanese population	• The normal face was judged favourably; however, an attractive profile might be different for each subject. • Highest ranking profiles (normal face and moderate mandibular retrusions) were often favourites, • Severe mandibular protrusions were liked the least by most subjects. • Other images showed a wide range of distribution. • Mandibular retrusion was generally more favoured than mandibular protrusion • Bimaxillary protrusion had a high attractiveness ranking and was well accepted in the Japanese population.
Maganzini et al., 2000	Facial profile: Lower face in sagittal plane	Ranking	Adult native Chinese male and female stimulus faces selected representative of average facial profile for this ethnic group. Four disproportional	• Native Chinese participants (from Beijing) • N=85 (47M, 38F)	• The native Chinese participants in this sample found that the profile distortions most acceptable were the 'flatter', or bimaxillary retrusive distortion, in the male stimulus face and the 'anterior divergent', or maxillary deficiency, in the female stimulus face.

Study	Facial parameter	Design	Images	Observers	Results
			facial profiles constructed Images represented skeletal or dental changes that differed by 2 SDs from the normative values for Chinese adults		
Maple et al., 2005	Facial profile: • Sagittal mandibular position • LAFH	Visual analogue scale (VAS)	Profile photographs (3M, 3F); Jaw position altered incrementally with Dolphin imaging	• Orthodontists (n=25) • Oral surgeons (n=25) • Laypeople (n=50)	• General concordance was found between providers and consumers in their perceptions of facial attractiveness. • Interactions of the anteroposterior and vertical dimensions and the magnitude of change in each dimension influence the perception of facial attractiveness.
McKoy-White et al., 2006	Facial profile: • Lip protrusion and retrusion, resembling bimaxillary	A computer program was used to adjust the lips, from very retrusive to very protrusive. A series of sequential	Manipulated photographs of 3 black female profiles	• White orthodontists (n=15) • Black orthodontists (n=15) • Black female patients	• White orthodontists preferred flatter profiles than the black women patients. • Black women patients preferred fuller profiles than the black orthodontists. • There are subjective differences in profile attractiveness among different ethnic groups. • There are subjective differences in profile attractiveness among orthodontists from different

Study	Facial parameter	Design	Images	Observers	Results
	protrusion and retrusion in profile view	frames was generated between the unaltered image, the retrusive extreme, and the protrusive extreme. Participants were asked to identify the most attractive profiles.		(n=15)	ethnic backgrounds. • Contrary to previous research, black women do not favour a flatter or more Caucasian profile.
Mejia-Maidl et al., 2005	Facial profile: • Lip protrusion and retrusion in profile view	Each of the observers asked to rate the attractiveness of the profile changes and the range of acceptability as the profile images were altered	Manipulated photographs of two male and two female persons of Mexican descent	• White Caucasians (n=30) • Mexican Americans (n=30)	• Mexican Americans preferred upper or lower lip positions to be less protrusive than did white Caucasians.
Meyer-Marcotty et	Frontal facial images:	• Images rated on a 6-point scale,	Eight randomly shown 3D	• Orthodontists (n=30)	• Observer profession did not influence the point at which asymmetry identified

Study	Facial parameter	Design	Images	Observers	Results
al., 2011	Nasal tip and chin symmetry	from 1=very symmetric to 6=very asymmetric	frontal facial images, with incremental 2mm alterations of nasal tip or chin.	• Maxillofacial surgeons (n=30) • Laypeople (n=30)	• All observers identified nasal asymmetries as more negative than chin asymmetries of the same extent • A left-sided nasal deviation led to a more negative rating • A right-sided chin deviation led to a more negative rating
Michiels and Sather, 1994	Facial profile	• Rating on visual analogue scale (VAS) • Specific reasons for scores	Profile photographs of random sample of 130 adult white women	6 judges: • Orthodontists • Oral surgeons	• Class II and convex profiles are less attractive than Class III profiles. • Reduced LAFH more acceptable than increased LAFH. • Judgment of facial appearance consistently related to certain regions of the face: the chin, upper lip, and nose having the greatest effect on the overall judgment of attractiveness.
Orsini et al., 2006	Facial profile: Mandibular prominence	• Investigated by using 3 methods: • A traditional semantic differential scale, • Perceptometrics method, • Implicit association test (IAT).	Variations in the sagittal position of the mandible	• White orthodontists (n=28) • White laypeople (n=56) • Japanese-American laypeople (n=55)	• Semantic differential scale - there is a general preference among orthodontists and laypeople for an orthognathic profile. • Perceptometrics method - orthodontists consider the most pleasing profile to be more forward than do lay subjects. • IAT - positive bias among all 3 groups toward orthognathic profiles and a negative bias toward profiles with mandibular retrognathism or prognathism. • IAT suggested that laypeople were more tolerant of mandibular prognathism in men than in women, and

Study	Facial parameter	Design	Images	Observers	Results
					more tolerant of mandibular retrognathia in white women than in men.
Park et al., 2006	Facial profile: Profile protrusion and retrusion (nose, lips, and chin)	Created movie using profiles – judges selected 'most pleasing position' and the 'zone of acceptability' as a measure of tolerance	Images of 1 male and 1 female Korean American adult were animated to move parts of the faces from an extreme retrusive position to an extreme protrusive position by using the Perceptometrics computer program.	• Korean American orthodontic patients (18), • Asian orthodontists (17) • Caucasian orthodontists (18)	• Korean American orthodontic patients preferred a more protrusive nose on the female image and more retrusive chin on the male image than Caucasian orthodontists. • Similar 'zone of acceptability' for all 3 groups.
Phillips et al., 1995	Facial profile	Four facial photographs of each subject were rank-ordered by the subject, a group of peers, 5	Four facial photographs of each of 19 female subjects recommended for the surgical correction of	• Orthodontists (5), • Maxillofacial surgeons (5), • Patients (19), • Laypeople	• Class I profiles are more attractive than Class II or Class III profiles • Class II patients who elected to undergo surgery were ranked least attractive by the peer and professional panels. • Virtually all subjects who reported psychological distress had elected to proceed with surgery.

Study	Facial parameter	Design	Images	Observers	Results
		orthodontists, and 5 oral surgeons. Several psychological tests were also completed by the subjects.	Class I (n=4) or Class II (n=15) malocclusion.		• Agreement is generally reached between patients, orthodontists, and oral surgeons regarding the level of facial attractiveness.
Shimomura et al., 2011	Facial profile: Bilabial prominence	Rating for attractiveness – observers asked choose the top 3 most-favoured, 'well-balanced' profiles for each gender.	13 male and 13 female profile silhouettes – created from 30 Japanese profiles with Class I occlusions. The lips were protruded or retruded by 1-mm increments from the average profile.	• Orthodontic patients (Japanese), (n=150)	• Orthodontic patients tended to prefer a slightly retruded lip position than the average facial profile for both the male and female profiles. • No significant difference between male and female raters in selecting the top 3 most-favoured profiles. • Comparison of age groups: the over 30-year-old patients significantly preferred a more retruded lip position than did the 15- to 19-year-old and the 20- to 29-year-old patients for the female profile.
Soh et al., 2005	Facial profile: Sagittal relationships of lower face	Ranking	Profile photographs 2 Chinese adults (1M, 1F); digital manipulation to	• Orthodontists (n=20) • Oral surgeons (n=11) • All from a	• A strong correlation in the profile assessment between orthodontists and oral surgeons. • Normal and bimaxillary retrusive Chinese male and female profiles were judged to be highly attractive by orthodontists and oral surgeons.

Study	Facial parameter	Design	Images	Observers	Results
			create 7 profiles for each sex. Images: bimaxillary protrusion, protrusive mandible, retrusive mandible, normal profile, retrusive maxilla, protrusive maxilla, and bimaxillary retrusion.	Singaporean community	• Chinese male and female profiles with protrusive mandibles were judged the least attractive. • Orthodontists preferred a flatter profile and oral surgeons preferred a fuller normal Chinese profile. • Gender of dental professionals and number of years in clinical practice were found to affect profile rankings.
Varlik et al., 2010	Frontal facial images: Lower anterior face height (LAFH)	• Silhouettes altered in 1-mm increments to create either taller or shorter LAFH • Photographs shown to laypeople • Rated on a 100-mm VAS	Frontal silhouette photographs of a male and a female; 'normal' male LAFH=81.5mm; female=70.5mm	• Laypeople (50M, 50F)	• Within 1 or 2 mm of deviation (both greater and lesser), the laypersons did not perceive a dislike of facial attractiveness. • With >2 mm of deviation (increase or decrease) in facial height, there was a statistically significant reduction in the perceived attractiveness of the face. • At >4 mm change, 75% of the evaluators recommended a need for treatment to correct the discrepancy in facial proportion.

1.6.2.2 Methods of measurement of perceived facial attractiveness

One of the main difficulties in measuring perceived facial attractiveness is that physical attractiveness is very difficult, if at all possible, to quantify. There are no specific gauges or instruments with which to measure facial attractiveness. Therefore, methods of assessment and measurement invariably rely on the attractiveness ratings or ordered rankings that a selected group of observers assign to viewed faces with specific configurations.

General agreement between large enough groups of observers as to the facial configurations that are deemed physically attractive may thus be taken as relatively quantifiable evidence of attractiveness. Where such agreement exists, researchers may use what is termed a 'truth by consensus' method to measure physical attractiveness.

1.6.2.2.1 'Truth by consensus' methodology

In philosophy, 'truth by consensus' is the process of taking statements to be true simply because people generally agree upon them. This is clearly a fallacy in terms of philosophy, as even if everyone's opinion is in agreement, those opinions may all nonetheless be erroneous. However, in the context of research into perceptions of physical attractiveness, the methodology is quite useful, and as a concept has a rather long history. Leonardo da Vinci advised that beautiful faces and figures should be chosen and measured in order to find 'ideal' proportions – but he stressed, 'make an effort to collect the good features from many beautiful faces, but *let their beauty be confirmed rather by public renown than by your own judgement'* [emphasis added] (Naini, 2011). This advice forms the foundation of modern research into perceptions of facial attractiveness (Naini, 2011).

1.6.2.2.2 Image types used in attractiveness research studies

A variety of quantitative methods are now available to assess perceived dentofacial morphology, many of which used standardized images (e.g. Index of Orthodontic Treatment Need, IOTN) (Brook and Shaw, 1989). Others use 2D or 3D imaging methods to display anthropometric information for determining the accuracy of the self perception as well as preferences for post treatment changes in the soft tissue profile, e.g. Dolphin Imaging (Lamichane et al., 2009). Nevertheless, these techniques still provide a series of static images from which observers make selections based on perceived attractiveness.

Some researchers have used facial photographs for aesthetic evaluation because seeing all the aspects of a patient's face gives arguably a truer portrayal of what is observed and whether observers' might interpret the face as attractive or not (Kerr and O'Donnell, 1990). However, a number of researchers have recommended the use of facial profile silhouette images as opposed to photographs in order to reduce the number of confounding variables, i.e. to reduce the influence of any unnecessary yet potentially distracting features (Foster, 1973; Coleman et al., 2007; Czarnecki et al., 1993). This method is thought to reduce the potential subjectivity or bias of gender or ethnic background of the subjects in the images and essentially eliminates extraneous aesthetic variables that may influence an observer, e.g. skin tone or complexion, cosmetics and hair colour or styling.

Facial profile silhouettes thereby provide a featureless, shape-based representation with minimal biases. However, there are some clear limitations to the face silhouette methodology. For example, it has been shown that certain parts of a face, such as the eyes, are important for face perception, recognition, and categorization, and these parts are not available in the silhouette representation (Brown and Perrett, 1993). Furthermore, silhouettes lack texture and colour information which are also known to contribute to recognition and perception of gender, age, and ethnic background (Bruce et al., 1993).

Davidenko (2007) compared the use of photographs with silhouettes for facial evaluation in psychological experiment and concluded that despite their limitations, the strengths of the use of silhouette images outweighed the limitations. Hockley et al. (2012) undertook a study to determine whether the use of facial profile photographs or silhouettes was a more appropriate method of evaluating African American profile aesthetics and whether there was different profile aesthetic preferences among clinicians when using photographs compared with silhouettes. They found that the attractiveness of faces of African American orthodontic patients was rated differently in photographs compared with silhouettes. When evaluating soft tissue aesthetic profile preferences, observer preferences in the photographs were closer to the established aesthetic norm than were their preferences in the silhouettes. Using silhouettes to evaluate patient attractiveness could influence clinicians or researchers to select profiles that are flatter than the established aesthetic norm.

However, although it may not be claimed that face silhouettes contain all the information used in face perception, in the context of research for clinical practice, such as finding quantifiable data for threshold values of desire for orthognathic and facial aesthetic surgery, the limitations discussed are also the reasons whereby the technique is useful.

1.6.2.2.3 Forced distribution or free category rating

In most studies the method used to measure facial attractiveness is either a forced distribution or a free category rating (Patzer, 1985). In the forced distribution method, otherwise termed ‘ranking’ method, observers are asked to sort a group of images into a forced normal distribution, e.g. the observers are advised to ‘please rank these images in order from the most to the least attractive’. However, the greater majority of researchers use the free category 'rating' method, which involves observers individually rating images along a continuum. The continuum endpoints may range from 'very attractive' to 'very unattractive', or may involve any potential verbal descriptions, though the concept is the same. Different scales may be used for the attractiveness continuum, as discussed below.

1.6.2.2.4 Attractiveness scales

The most often used attractiveness scale is a bipolar Likert scale, though the number of points used is variable. A Likert scale is a psychometric scale commonly involved in research that employs questionnaires. It is the most widely used approach to scaling responses in survey research, such that the term is often used interchangeably with 'rating scale', or more accurately the 'Likert-type scale'. The scale is named after its inventor, the psychologist Rensis Likert (Likert, 1932). The Likert technique presents a set of attitude statements. When responding to a Likert questionnaire item, respondents specify their level of agreement or disagreement on a symmetrical agree-disagree scale for a series of statements. The Likert scale is the sum of responses on several 'Likert items'. A Likert item is simply a statement which the respondent is asked to evaluate according to any kind of subjective or objective criteria. Generally the level of agreement or disagreement is measured. It is considered symmetric or 'balanced' because there are equal amounts of positive and negative positions. Often five ordered response levels are used, although some researchers advocate using seven or nine levels.

Likert scaling is a bipolar scaling method, measuring either positive or negative response to a statement. Sometimes an even-point scale is used, where the middle option of 'Neither agree nor disagree' is not available. This is sometimes called a 'forced choice' method, since the neutral option is removed. The neutral option can be seen as an easy option to take when a respondent is unsure, and so whether it is a true neutral option is questionable. It has been shown that when comparing between a 4-point and a

5-point Likert scale, where the former has the neutral option unavailable, the overall difference in the response is negligible (Armstrong, 1987).

'Consensus based assessment' (see above) may be used to create an objective standard for Likert-type scales in domains where no generally accepted standard or objective standard exists, such as in the perceived attractiveness of human faces.

Occasionally, researchers studying perceptions of facial attractiveness have opted for a different type of scale, termed a visual analogue scale (VAS) (Hall et al., 2000; Maple et al., 2005; Michiels and Sather, 1994). On a VAS, respondents specify their level of agreement to a statement by indicating a position along a continuous line between two end-points. This continuous (or 'analogue') aspect of the scale differentiates it from discrete scales such as the Likert-type scale.

A type of observer bias that may occur with Likert or visual analogue scales, termed central tendency bias (or 'end aversion'), is where observers have an unconscious tendency to avoid extreme categories, thereby essentially constricting the range of possible responses. This is often seen as more of a problem with VAS compared with Likert-type rating scales. With the Likert-type scale, this bias may be mitigated by adding extra categories at the ends of the scale in order to preserve the spectrum of genuine responses.

1.6.2.2.5 Perceptometrics™ and 'zones of acceptability'

A novel approach introduced by Giddon (1995) used computer morphing of the continuously changing profile image to provide a range rather than a series of discrete images, in this case of the preferred outcome of treatment. This so-called Perceptometrics™ method presents computer altered photographic images of selected features of the soft tissue profile which are continuously morphed in counterbalanced order between retrusive and protrusive extremes of the maxilla and mandible. Patients press the mouse button to indicate the beginning of the acceptable range of changes in profiles and release the button when the changes are no longer acceptable. From this the midpoint of the range (in millimetres, corrected for actual size) may be determined, as well as the 'zone of acceptability', within which a studies facial parameter is deemed to be within normal limits, in terms of perceived attractiveness (Giddon et al., 1996). The Perceptometrics™ method has been used in a number of studies to explore the influence of variations in different facial parameters on perceived attractiveness (Arpino et al. 1998; McCoy-White et al., 2006; Mejia-Maidl et al., 2005; Orsini et al., 2006; Park et al., 2006).

For example, a study by Arpino *et al.* (1998) analyzed five facial profile features, including sagittal mandibular position, using the profile images of 11 patients scheduled for orthognathic surgery limited to the mandible (i.e., set-back or advancement). The images were animated for continuous change with customized morphing software and video imaging. The observers included 11 presurgical orthognathic patients, the patient's 'significant other', 3 orthodontists and 3 oral surgeons. As the mandibular protrusion animated between two extremes, the 'zone of acceptability' was established by the observers pressing the computer mouse when the changing feature became acceptable and releasing the button when the image was no longer acceptable. In a separate task, the observers were asked to indicate the most pleasing mandibular position. The results demonstrated that all the observer groups had similar preferences and that orthognathic patients had the lowest tolerance for deviation from the preferred image.

Hier et al. (1999) compared the preferences for lip prominence between orthodontic patients and untreated subjects, finding that for both genders the untreated group preferred more prominent lips than orthodontically treated patients. Miner et al. (2007) compared the self-perception of child patients with their mothers and treating clinicians. They found that both the patients and their mothers overestimated the prominence of the child's mandible, which was consistent with both groups preferring a more prominent lower facial profile for the child. In addition, mothers had the narrowest zone of acceptability of tolerance for change in the facial soft tissue profile.

1.6.2.3 Participants (observers) used in attractiveness research studies

A variety of terms are used to describe the participants in an attractiveness research study, such as ‘participants’, ‘observers’, ‘judges’, ‘responders’ or ‘raters’. Whichever term is used by the studies authors, it should be mandatory to specify the ‘type’ or ‘group’ of observers, e.g. patients, clinicians or laypeople. Further specific information about each observer group would also be required, such as age, gender, ethnic background, type of clinician (e.g. orthodontist or maxillofacial surgeon), years of experience as a clinician, educational level of laypeople, geographical region (Kiekens et al., 2007) and any other data that may be deemed relevant to the study.

The attractiveness studies mentioned above demonstrate the importance of considering the age, gender and ethnic background of observer groups and their potential influence on perceptions of facial attractiveness. In addition, they serve as a reminder to clinicians of the need to be sensitive to differences in perception between patients, laypeople and clinicians. Patients do not always want to alter aspects of their facial appearance in relation to the clinician’s preferred outcome.

1.6.2.3.1 Clinicians vs. patients vs. laypeople

In terms of perception of facial attractiveness, it may be conjectured that clinicians may develop higher critical faculties because of their training. It may also be that the very existence of a facial deformity may lead to patients developing a greater sensitivity to noticeable differences in facial appearance from the norm. For example, previous studies have found significant differences between the perceptions of facial profile attractiveness of orthodontists and maxillofacial surgeons compared with laypeople (Cochrane et al., 1999). Differences have also been demonstrated to exist between orthognathic patients and clinicians in terms of perceived need for orthognathic surgery. Juggins et al. (2005) recruited forty patients from combined orthodontic-surgical clinics. They were asked to rate their perceived need for treatment based on facial appearance, dental appearance, function, and overall need. Twenty orthodontists and 20 maxillofacial surgeons were asked to rate perceived need for treatment of the patients based on the same parameters, using study models and clinical photographs. Significant differences were found between patients and clinicians in perceived need for treatment based on facial appearance. Clinicians rated greater need for orthognathic treatment based on facial appearance than did patients. Surgeons also rated greater overall need for treatment than patients. In addition, surgeons rated treatment need based on facial appearance and function significantly higher than orthodontists, but large variations existed in both clinician groups.

Attractiveness studies often use laypeople as observers but seldom use patients (Table 1.2). If the results of further investigation reveal that orthognathic patients are more critical than laypeople, then it may be suggested that in future studies greater emphasis may be put on evaluating the perceptions of patients as opposed to only laypeople.

Table 1.2 Types of observers used in previous attractiveness studies

Orthognathic patients	Orthodontic patients	Parents of orthodontic patients	Orthodontists	Maxillofacial surgeons	Dentists	Dental students	Students (other)	Laypeople	Patient's spouse	Professionals (unspecified)
Arpino et al., 1998			Arpino et al., 1998	Arpino et al., 1998					Arpino et al., 1998	
			Cochrane et al., 1999	Cochrane et al., 1999		Cochrane et al., 1999		Cochrane et al., 1999		
	Coleman et al., 2007	Coleman et al., 2007	Coleman et al., 2007							
										Czarnecki et al., 1993
						De Smit and Dermaut, 1984		De Smit and Dermaut, 1984		
			Foster, 1973		Foster, 1973		Foster, 1973	Foster, 1973		
			Hall et al., 2000					Hall et al., 2000		
					Hönn et al., 2005			Hönn et al., 2005		
			Ioi et al., 2007			Ioi et al., 2007				
							Johnston C et al., 2005a,b			

Orthognathic patients	Orthodontic patients	Parents of orthodontic patients	Orthodontists	Maxillofacial surgeons	Dentists	Dental students	Students (other)	Laypeople	Patient's spouse	Professionals (unspecified)
		Kerr and O'Donnell, 1990	Kerr and O'Donnell, 1990			Kerr and O'Donnell, 1990	Kerr and O'Donnell, 1990			
			Knight and Keith, 2005					Knight and Keith, 2005		
								Maganzini et al., 2000		
			Maple et al., 2005	Maple et al., 2005				Maple et al., 2005		
	McKoy-White et al., 2006		McKoy-White et al., 2006							
								Mejia-Maidl et al., 2005		
			Meyer-Marcotty et al., 2011	Meyer-Marcotty et al., 2011				Meyer-Marcotty et al., 2011		
			Michiels and Sather, 1994	Michiels and Sather, 1994						
			Orsini et al., 2006					Orsini et al., 2006		
	Park et al., 2006		Park et al., 2006							
Phillips et al., 1995			Phillips et al., 1995	Phillips et al., 1995				Phillips et al., 1995		
	Shimomura et al., 2011									

Orthognathic patients	Orthodontic patients	Parents of orthodontic patients	Orthodontists	Maxillofacial surgeons	Dentists	Dental students	Students (other)	Laypeople	Patient's spouse	Professionals (unspecified)
			Soh et al., 2005	Soh et al., 2005						
								Varlik et al., 2010		

1.6.2.3.2 Ethnic background of observers

The ethnic background of observers may play a crucial role in their perceptions of facial attractiveness. Foster (1973) compared the perceptions of White, Black and Chinese laypeople in evaluating bilabial prominence but found that all groups were consistent in assigning slightly more prominent lips as most attractive. However, the groups may well have been exposed to similar environments. Hall et al. (2000) compared the perceptions of White and African American orthodontists and White and African American laypeople in relation to facial profile attractiveness. All the observers preferred the African American sample to have a greater profile convexity and to have upper and lower lips that were more prominent compared with the white sample. However, the African American orthodontists differed from the other observer groups when rating the African American images in terms of lip prominence. This demonstrates that even clinical training may not create the same attractiveness 'ideals' between clinicians from different ethnic backgrounds. McKoy-White et al. (2006) compared the perceptions of white and black orthodontists and black female orthodontic patients in relation to bilabial prominence. Their results were particularly interesting, in that they found differences among different ethnic groups and between orthodontists from different ethnic backgrounds. Black female patients did not favour a 'flatter' or more bilabially retrusive profile from their ethnic norm. Mejia-Maidel et al. (2005) found that Mexican Americans in general preferred less prominent lips than white Caucasians. Interestingly, although it was conjectured that the Mexican American population may have assimilated more white Caucasian-type aesthetic values, this was not confirmed by the results of the study. Orsini et al. (2006) compared the perceptions of white orthodontists and white laypeople to Japanese American laypeople in relation to mandibular prominence. Although some difference was found between orthodontist and laypeople, there was little difference between the white and Japanese American groups, which again may be related to sharing similar environments.

1.7 Aims of the Thesis

The aims of this thesis were:

- To undertake an objective, quantitative evaluation of the influence of the severity of the disproportion of various facial parameters on perceived attractiveness.
- To examine the relationship between the type and degree of deviation of each facial parameter from the 'ideal' and the attractiveness ratings recorded in order to find the range of normal variability for each facial parameter, in terms of observer acceptance.
- To find the threshold values of desire for surgical correction for the various facial parameters.
- To compare the perception of orthognathic patients, laypeople and clinicians.

1.8 Null hypotheses

Part 1 (chapter 3): There is no effect of the proportion of the craniofacial height to standing height proportion on perceived attractiveness. Likewise, there is no difference in the perception of laypeople and clinicians.

Part 2 (chapters 4-8): There is no effect of the type or degree/severity of the deviation of each facial parameter studied on perceived attractiveness and desire for surgery. Likewise, there is no difference in the perception of orthognathic patients, laypeople and clinicians.

Part 3 (chapter 9): There is no effect of combined orthodontic-orthognathic surgical treatment on patients' perceptions of attractiveness and their desire for surgical correction.

2 Materials and Methods

This chapter describes the materials, subjects and methods that were employed in the production of this thesis. More specific details of any methods have been described in each relevant results chapter as required.

The thesis is divided into three main parts:

- Part 1: Assessing the influence of craniofacial to standing height proportion on perceived attractiveness (described in chapter 3)
- Part 2: Assessing the influence of various lower facial parameters, in frontal and profile views, on perceived attractiveness (described in chapters 4 to 8)
- Part 3: A longitudinal study to assess the effects of orthognathic surgery on perceptions of attractiveness (described in chapter 9)

2.1 Part 1: Assessing the influence of craniofacial to standing height proportion on perceived attractiveness

The purpose of this part was to investigate the influence of the proportion of the craniofacial height to standing height on the attractiveness of images as perceived by the lay public and clinicians involved in the management of patients with facial deformities.

2.1.1 The images

Leonardo da Vinci's image of *Vitruvian Man* (Figure 3.2) was manipulated by computer software (Adobe® Photoshop® CS2 software; Adobe Systems Inc, San Jose, CA) to produce a standardised image of a man with outstretched arms. A standardised male face was drawn, with the same computer software, with 'ideal' facial proportions based on currently accepted criteria (Naini, 2011), and bilateral facial symmetry (see section 2.2.1). The created face and body were pasted together (Figure 2.1). All the images created and their manipulations were undertaken by the author. Using Photoshop image-processing software the vertical craniofacial height was digitally altered from a proportion of 1/6 of standing height to 1/10 of standing height. The proportion of the equal vertical facial thirds was maintained in all the images. Nine images were thus created with a craniofacial height to standing height proportion of 1/6, 1/6.5, 1/7, 1/7.5, 1/8, 1/8.5, 1/9, 1/9.5 and 1/10. The accuracy of the measured adjustments was rechecked by the author using the Photoshop software measurement tool. A randomly selected duplicate of one of the images was used in order to assess intra-examiner reliability.

Each of the ten images was printed onto a separate A4-size photographic paper with a matte finish. There were no other identifiable marks on the paper. Each photograph was ascribed by an exclusive symbol on its posterior surface as a code for identification when tabulating the results.

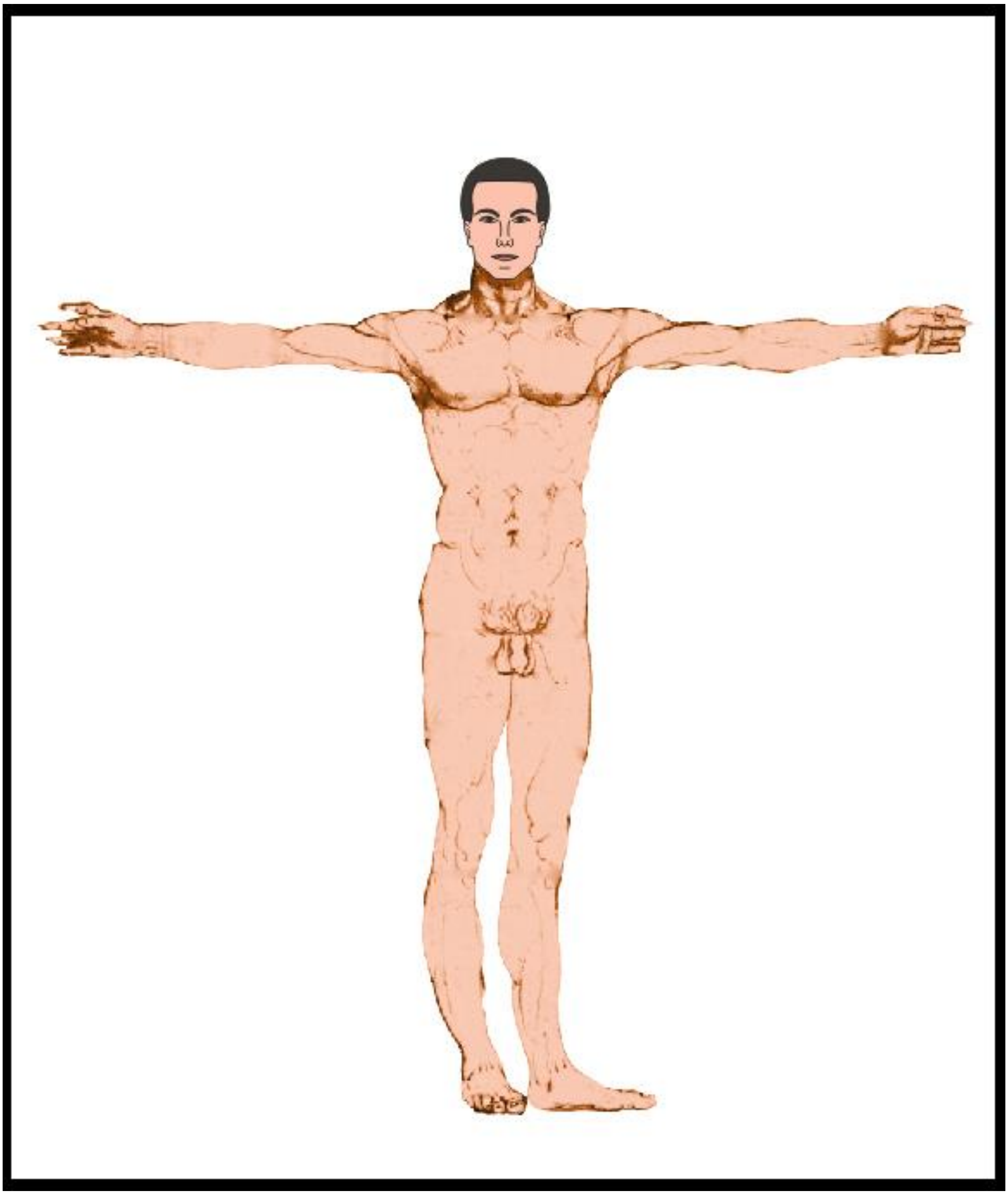

Figure 2.1 An idealized male head pasted onto the image of the *Vitruvian Man*

2.1.2 The observers, questionnaire and ranking method

A total of 89 observers took part in the study. These included 74 non-clinical lay people (45 female; White=43; Black=11; Asian=20), chosen from within the Greater London area, and 15 clinicians (3 female; White=12; Asian=3) involved in the management of patients with facial deformities. The clinicians were either consultant or senior registrar level. Each observer was provided with a questionnaire asking their age (in years), gender (male/female) and ethnicity (White, Black, Asian or Oriental). Observers undertook the ranking exercise individually. Each observer was shown the 10 photographic images, arranged in random order. The only difference between the images was the proportion of the craniofacial height to the standing height. The observers were asked to arrange the images in order from the most to the least attractive. The images were thereby ranked from the most to the least attractive.

2.2 Part 2: Assessing the influence of various facial parameters, in frontal and profile views, on perceived attractiveness

Two-dimensional facial profile silhouettes have been routinely used to assess the perceptions of facial profile attractiveness. However, it is not easily possible to assess frontal facial views using silhouettes. Therefore, idealized two-dimensional frontal facial views were created using computer software.

2.2.1 Front face images

A male and a female frontal facial image was created with computer software (Adobe® Photoshop® CS2 software; Adobe Systems Inc, San Jose, CA). The two images were then manipulated using the same computer software to construct an 'ideal' male and an 'ideal' female symmetrical frontal facial image with proportions (Naini, 2011) and soft tissue measurements (Farkas et al., 1984; Farkas et al., 1985; Farkas et al., 1986; Farkas and Kolar, 1987; Farkas, 1994; Naini, 2011) based on currently accepted criteria (Figures 2.2 and 2.3):

(i.e., vertical facial trisection; vertical facial bisection; upper lip to lower lip/chin height proportion; transverse rule-of-fifths; bitemporal width - bizygomatic width - bigonial width ratio; mouth width – equal to the distance between the medial iris margins; total face height; lower anterior face height; upper lip height; upper vermilion height; lower lip height; lower vermilion height; lower lip/chin height; vertical position of mentolabial fold; nasal height; nasal width; nasal alar base width; interpupillary width; eye width; eye shape; eyebrow position and shape; ear position and height).

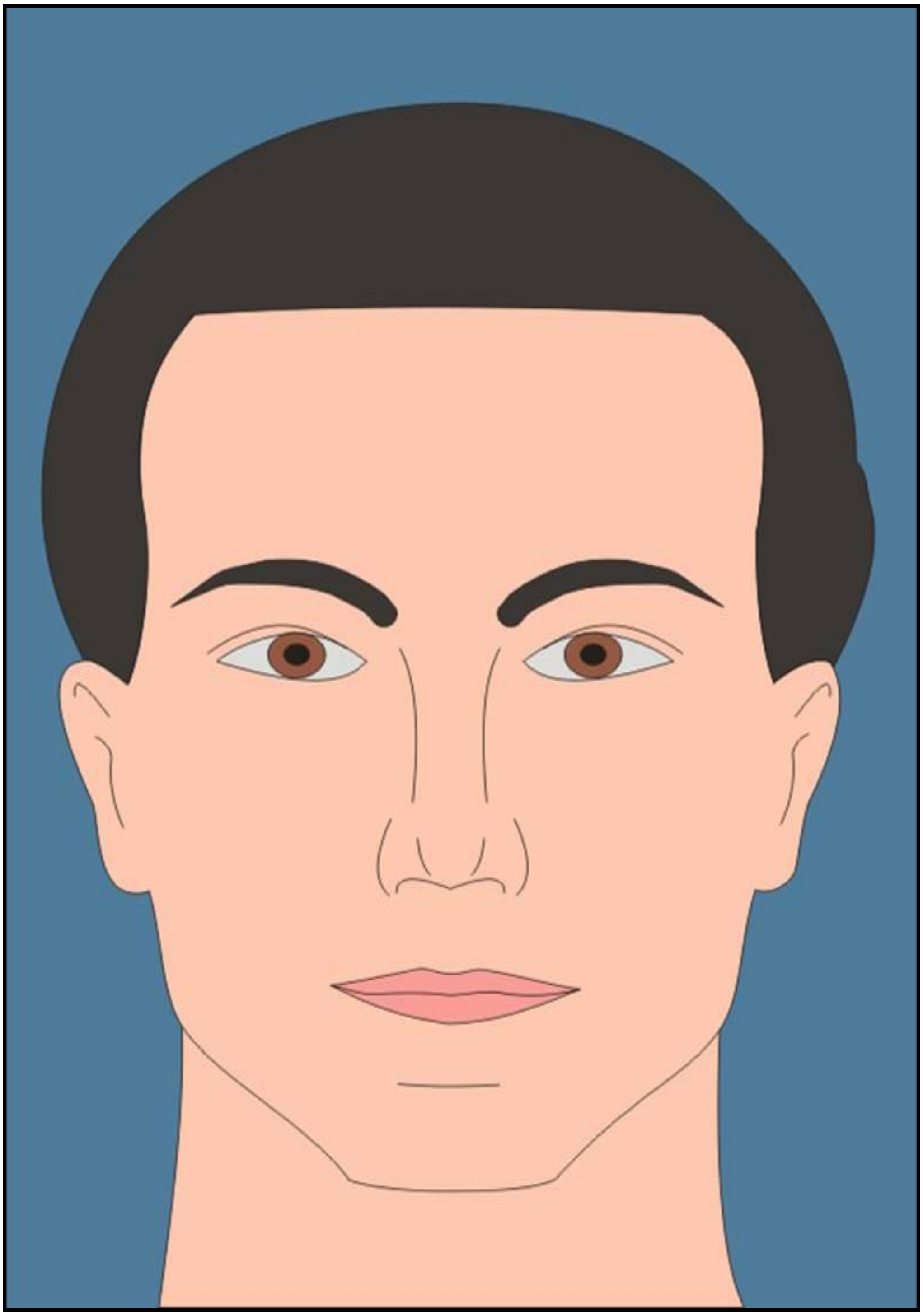

Figure 2.2 Idealized male front face image

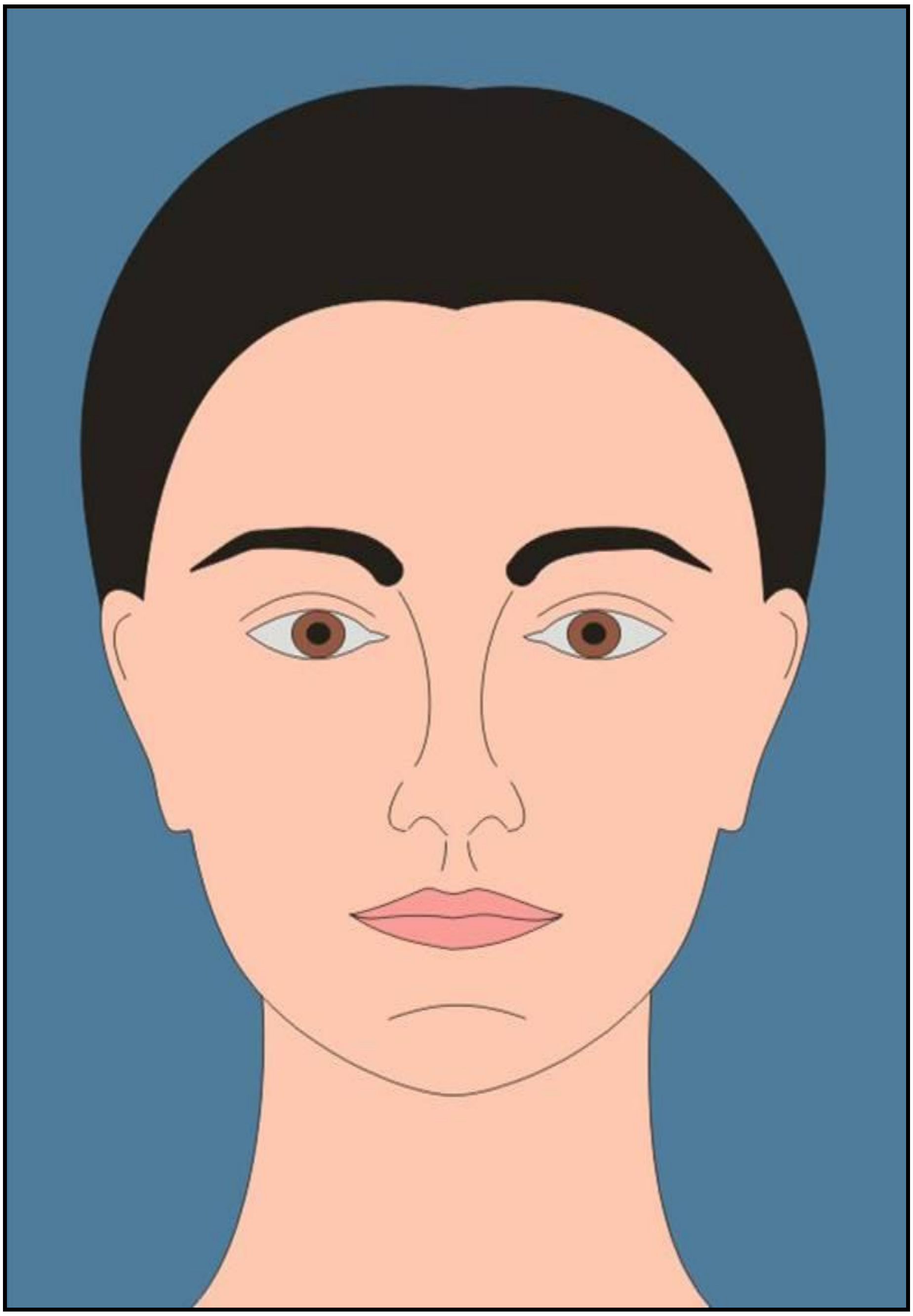

Figure 2.3 Idealized female front face image

2.2.2 Profile image

A facial profile silhouette image was created with computer software (Adobe® Photoshop® CS2 software; Adobe Systems Inc, San Jose, CA). This was based on the facial profile of a white Caucasian male, whose profile was deemed by the author to be well-proportioned and attractive. The image was then manipulated using the same computer software to construct an 'ideal' facial profile image with proportions (Naini,

2011) and soft tissue measurements (Farkas et al., 1984; Farkas et al., 1985; Farkas et al., 1986; Farkas and Kolar, 1987; Farkas, 1994; Naini, 2011) based on currently accepted criteria (Figure 2.4 and 2.5):

Facial trisection (facial thirds equal – trichion to glabella, glabella to subnasale, subnasale to menton); lower facial third: upper lip – subnasale to stomion (1/3), lower lip and chin – stomion to menton (2/3); Sagittal position of glabella, subnasale and pogonion to zero-degree meridian line; 'Ideal' values for: Nasofrontal angle; Nasofacial angle; Nasolabial angle; Mentolabial angle; Mentolabial depth; Lip-chin-throat angle; Throat-neck angle; Submental length; Lips to E-line; Lips to S-line.

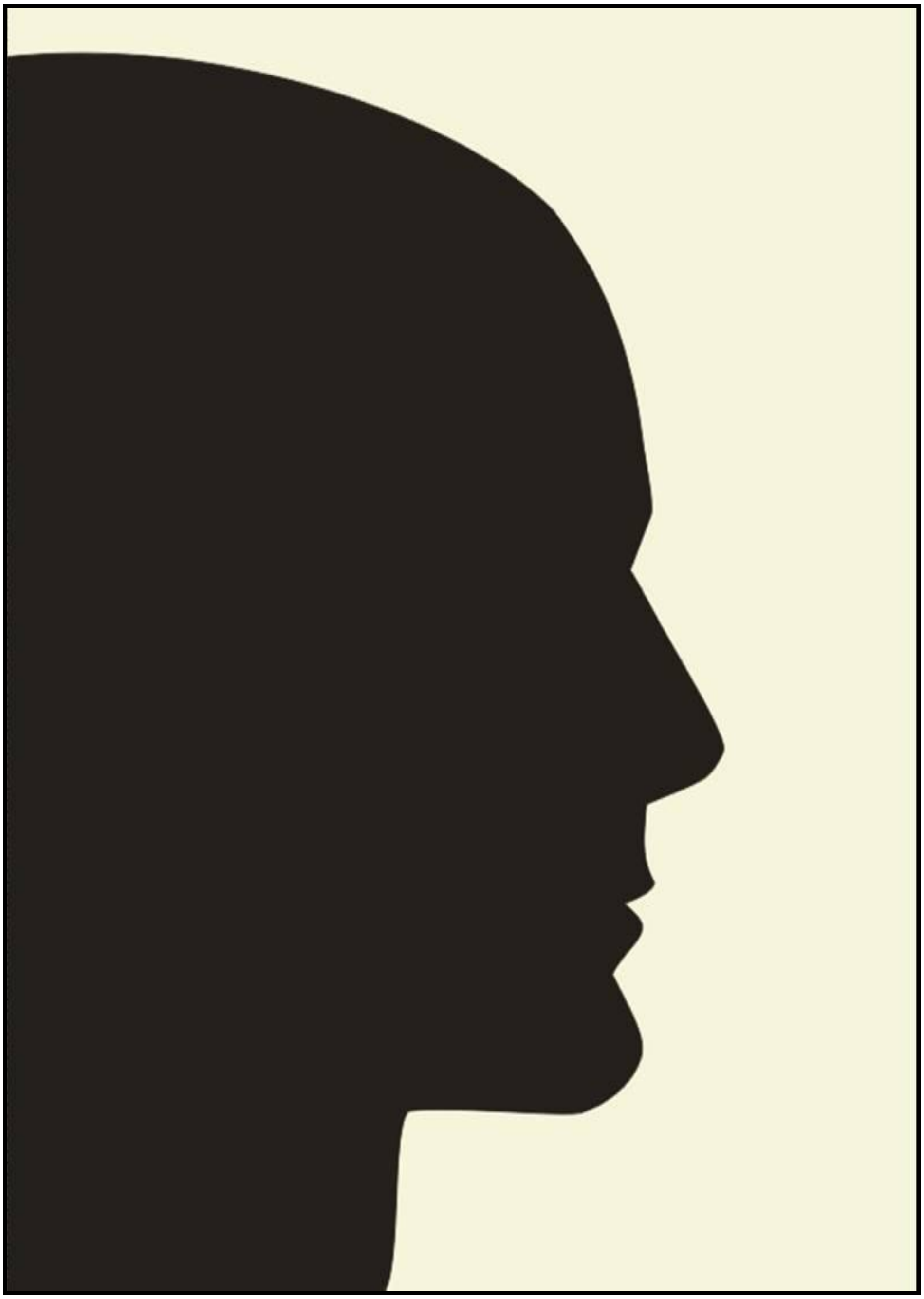

Figure 2.4 Idealized profile image

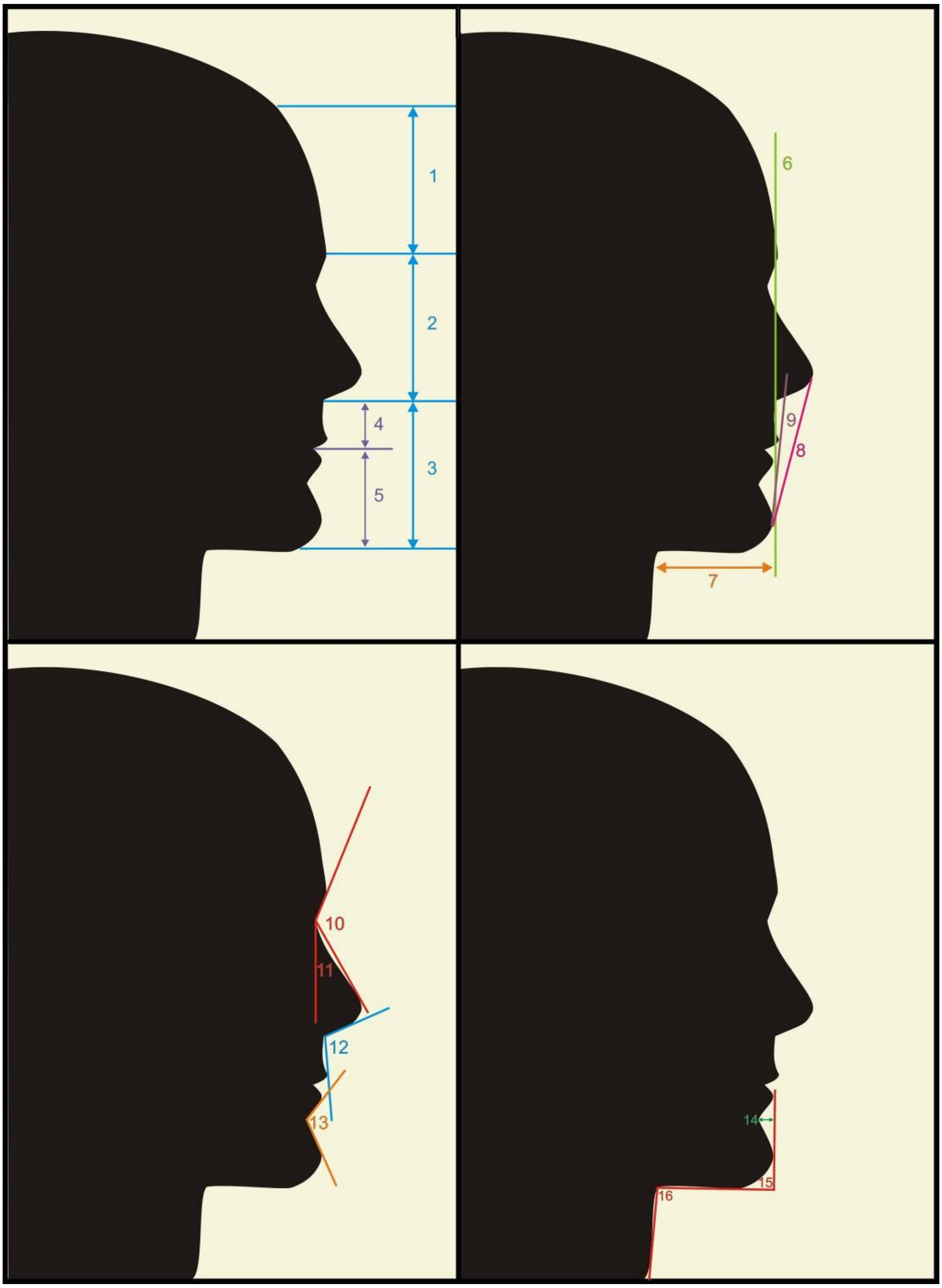

Figure 2.5 'Ideal' facial profile image with facial parameters based on currently accepted criteria: Facial trisection (facial thirds equal: 1. trichion to glabella, 2. glabella to subnasale, 3. subnasale to menton); lower facial third: 4. upper lip height –subnasale to stomion (1/3), 5. lower lip and chin height – stomion to menton (2/3); 6. Sagittal position of glabella, subnasale and pogonion to zero-degree meridian line; 7. Submental length; 8. Lips to E-line; 9. Lips to S-line. 'Ideal' values for: 10. Nasofrontal angle; 11. Nasofacial angle; 12. Nasolabial angle; 13. Mentolabial angle; 14. Mentolabial depth; 15. Lip-chin-throat angle; 16. Throat-neck angle.

2.2.3 Image manipulation (incremental)

Having created the idealized images, in each chapter one specific lower facial parameter was incrementally altered in order to create a range of images, which could then be rated in terms of attractiveness.

- Chapter 4: Chin height - The images were manipulated in 2.5 mm increments, from -12.5 to 22.5 mm for the male images and from -10 to 20 mm for the female images, representing both reduction and increase in chin height.
- Chapter 5: Mandibular and chin point asymmetry - The male and the female images were manipulated, to the left and the right, in 5 mm increments from 0 to 25 mm, in horizontal (corresponding to the mandibular and chin point asymmetry viewed in hemimandibular elongation), vertical (corresponding to the asymmetry viewed in hemimandibular hyperplasia) and combined horizontal and vertical directions.
- Chapter 6: Lower face convexity - The lower facial plane (subnasale to soft tissue pogonion) of the image was manipulated, in 2 degree increments, from 0 to 14 degrees backwards (section 1) and from 0 to -16 degrees forwards (section 2), rotating around subnasale, in order to represent increased and reduced lower facial profile convexity respectively.
- Chapter 7: Chin prominence - The idealised profile image was altered in 2 mm increments from -24 to 12 mm, in order to represent retrusion and protrusion of the chin respectively.
- Chapter 8: Mandibular prominence - The idealised profile image was altered in 2 mm increments from -16 to 12 mm, in order to represent retrusion and protrusion of the lower jaw respectively.

2.2.4 Ethical approval

Ethical approval was sought and granted for the study (National Research Ethics Service, UK; REC reference 06/Q0806/46); (see Appendix).

2.2.5 The observers

A pilot study was undertaken in order to perform a power calculation. The pilot study was undertaken with 35 pre-treatment orthognathic patients, 35 laypeople and 7 clinicians. The data from these observers was carried forward into the results of the main study. Based on the results of the pilot study, the anticipated standard deviations of rating were 1.0 in all groups of observers. Our study aimed to recruit 35 clinicians, 75 pre-treatment orthognathic patients and 75 laypeople to guarantee 80% power to detect differences in the mean rating score of approximately 2.5 in the clinician group vs. 3.1 in the patient and laypeople groups (this corresponds to a standardised mean difference of 0.6). A total of 185 observers took part in the study, separated into 3 groups (pre-treatment orthognathic patients, laypeople and clinicians) (Table 2.1). The observers jaw relationships are demonstrated in table 2.2.

Table 2.1 Observer demographics (CI, confidence interval)

Observer Group	Number	Mean age (in years)	95% CI	Age range	Gender (% Male)	Ethnicity (% White)
Orthognathic Patients	75	22	20-24	13-60	42%	66%
Laypeople	75	31	28-35	16-79	31%	49%
Clinicians	35	31	30-33	24-39	33%	72%

Table 2.2 Observer's jaw relations

Jaw relationship	Orthognathic patients	Laypeople	Clinicians	Total
Class I	3 (4%)	75 (100%)	35 (100%)	113 (61%)
Class II	37 (49.3%)	0	0	37 (20%)
Class III	35 (46.7%)	0	0	35 (19%)

2.2.5.1 Selection criteria

Selection of the three groups of observers followed the selection criteria described below:

- Orthognathic patients
  - Selection criteria
    - Pre-treatment
    - Primary concern was facial appearance
    - No previous orthodontic or facial surgical treatment
    - No history of facial trauma
    - No severe psychological issues, e.g. body dysmorphic disorder
- Laypeople
  - Selection criteria
    - No previous orthodontic or facial surgical treatment
    - No facial deformities
    - No history of facial trauma
- Clinicians involved in the management of facial deformities

The pretreatment orthognathic patients were recruited from the author's new patient clinics. At the end of the first brief consultation, if a patient agreed to potentially take part in the study, they were provided with an information sheet (see Appendix). An appointment was made for data collection, prior to which, if the patient was happy to continue with the study, they signed a formal consent form to take part in the study (see Appendix). The laypeople group were all non-clinical individuals, recruited in the Greater London area.

2.2.6 The Questionnaire

Each observer was given a questionnaire, created by the author, thanking them for agreeing to take part in the research. The observers were asked to provide the following information: age, gender, ethnic origin (White or non-White Caucasian), handedness (right or left-handed), how would you rate the attractiveness of *your* facial appearance (very unattractive; unattractive; attractive; very attractive), and how important do you think it is to have an attractive facial appearance (very unimportant; unimportant; important; very important).

The observers rated each facial image using the following scale:

1. Extremely unattractive
2. Very unattractive
3. Slightly unattractive
4. Neither attractive nor unattractive
5. Slightly attractive
6. Very attractive
7. Extremely attractive

In addition, observers were asked whether *they* would consider surgery to correct the appearance if this was *their* facial appearance.

The images were placed in random order into Microsoft PowerPoint®. Each image was identified by a randomly assigned double letter in the top right corner of the screen (e.g. BC). A duplicate of one of the images in each group, randomly selected, was used in order to assess intra-examiner reliability. Each observer undertook the study alone in a room with one computer and monitor. As far as the author could ascertain none of the patients knew each other, and the observers had not discussed the project with anyone prior to undertaking the study. No payment of any kind was provided to any observer. Each observer sat undisturbed in the same room in front of the same computer and 17" flat screen monitor. The presentation and the images were created in such a way that each of the images, when viewed on the 17" flat screen monitor, had the same dimensions as a normal human head, based around an average lower anterior facial height. This would help to reduce the potential effect of image magnification or size reduction on the observer's perception. The images were separated into sections. Each section included the images for the one parameter being assessed e.g. section 1 included the images for chin height etc. Within each section, the images were in random order. The observers looked at all the images in one sitting. No time limit was set, though most observers completed the study within 30 to 45 minutes. Each observer examined the images in the PowerPoint® presentation by pressing the 'Page Down' button on the keyboard, in their own time.

2.2.7 The rating method

The Likert-type rating scale is largely accepted in the psychology literature as the most useful rating method (Langlois et al., 2000). The seven-point Likert scale described above was used by each observer to rate each image in terms of attractiveness. An example of a section of the questionnaire is provided below (Figure 2.6).

IMAGE	**RATING (Please circle)**	**Would you consider surgery if this was *your* facial appearance? (Please circle)**
DD	**1 2 3 4 5 6 7**	**YES / NO**
VE	**1 2 3 4 5 6 7**	**YES / NO**
LB	**1 2 3 4 5 6 7**	**YES / NO**

Figure 2.6 An example of a section of the questionnaire

2.2.8 Statistical analysis

The observer's ratings were recorded in a Likert scale from 1 to 7. Mixed regression was used to assess the differences in ratings for the three groups (pre-treatment orthognathic patients, laypeople, and clinicians) while adjusting for the concurrent effects of age, gender, ethnicity, self-rating for facial attractiveness, the importance given to an attractive facial appearance, the observer's anteroposterior jaw relationship (Class I, II or

III), the observer's vertical face height (average, increased or decreased), observer's facial asymmetry (yes/no) and the degree/type of variation in the respective lower facial parameter being studied. The observer's anteroposterior jaw relationship, vertical face height and presence or absence of a facial asymmetry was analyzed for the orthognathic patient group based on formal clinical and cephalometric evaluation. Both in terms of clinical and cephalometric evaluation, a patient was only placed in categories for skeletal Class II or III, or vertical face height increased or decreased, or presence of a facial asymmetry, if the parameter was to be taken into account for orthognathic correction. For the laypeople and clinician groups these parameters were guesstimated from an informal appraisal of the individual's frontal facial and profile appearance, by visual assessment, undertaken by the author.

The multivariate regression models are fitted in a stepwise manner, including all those variables that reach a significance below P=0.25 univariately. Given the recognised low power of the relevant test, the benchmark for a significant interaction was set at the 10% level. The mixed regression uses a multi-level approach to take into account the clustering effect by observer. The model was validated using a logarithmic transformation for the rating scale to assess the effect of departure from normality.

2.3 Part 3: A longitudinal study to assess the effects of orthognathic surgery on perceptions of attractiveness

The principle aim of this investigation was to quantitatively evaluate the influence of combined orthodontic-orthognathic surgical treatment on patients' perceptions of attractiveness and their desire for surgical correction.

2.3.1 The images

A facial profile silhouette image was created as described in section 2.2.2.

2.3.1.1 *Profile image manipulation (incremental)*

The mandibular prominence of the idealised profile image was altered in 2 mm increments from -16 to 12 mm, in order to represent retrusion and protrusion of the lower jaw respectively.

2.3.2 *The observers, questionnaire and rating method*

2.3.2.1 *Observers*

From a group of 75 pre-treatment orthognathic patients recruited for part 2 of this thesis research study (chapter 8), 50 orthognathic patients having completed orthognathic treatment (6-months following removal of the orthodontic appliances), were recruited as observers in this study (Table 2.2). The sample size of 50 patients guaranteed 80% power to detect a mean standardized difference of 0.8 and above between the two groups being compared. The observers were recruited using the selection criteria described below:

- Selection criteria:
    - Primary concern had been facial appearance
    - No previous orthodontic or facial surgical treatment
    - No history of facial trauma
    - No severe psychological issues e.g. body dysmorphic disorder

Table 2.3 Observer demographics (CI, confidence interval)

Observer Group	Number	Mean age (years)	95% CI	Age range	Gender (% male)	Ethnicity (% White)
Orthognathic Patients	50	22	21.5 - 22.5	15 - 48	48%	60%

2.3.2.2 *Questionnaire*

After the initial consultation appointment, each observer was given a questionnaire and asked to provide the following information: age, gender, ethnic origin, right or left-handedness, how would you rate the attractiveness of *your* facial appearance, and how important do you think it is to have an attractive facial appearance. An instruction sheet accompanied the questionnaire, asking the observers to rate each image in terms of facial attractiveness using the following rating scale:

1. Extremely unattractive
2. Very unattractive
3. Slightly unattractive
4. Neither attractive or unattractive
5. Slightly attractive
6. Very attractive
7. Extremely attractive

In addition, observers were asked whether they would consider surgery to correct the appearance if this was their facial appearance (yes or no).

The images were placed in random order into Microsoft PowerPoint®. Each image was identified by a randomly assigned double letter in the top right corner of the screen (e.g. BC). A duplicate of one of the images in each group was used in order to assess intra-examiner reliability. Each observer sat undisturbed in the same room in front of the same computer and 17” flat screen monitor. The presentation and the images were created in such a way that each of the profile silhouette images, when viewed on the 17” flat screen monitor, had the same dimensions as a normal human head, based around an average lower anterior facial height. This would help to reduce the potential effect of image magnification or size reduction on the observer’s perception. Each observer examined the images in the PowerPoint® presentation by pressing the ‘Page Down’ button on the keyboard, in their own time.

2.3.2.3 Rating method

The Likert-type rating scale is largely accepted in the psychology literature as the most useful rating method (Langlois et al., 2000). The seven-point Likert scale described above was used by each observer to rate each image in terms of attractiveness. The data collected after this first consultation appointment formed the baseline data (T1). The patients then proceeded to undergo and successfully complete combined orthodontic-orthognathic surgical treatment. At the 6-month review appointment following removal of the orthodontic appliances and retainer wear, the observers completed the questionnaire again and underwent exactly the same data acquisition procedure using the same images in the same order in the same conditions, forming the follow up data (T2).

2.3.3 Statistical analysis

The baseline data was collected at the first consultation appointment (T1). The patients underwent combined orthodontic-orthognathic surgical treatment (single jaw or bimaxillary surgery). A second set of data was collected on a follow up visit, 6-months following debond of the orthodontic appliances (T2). The main outcomes were a measure of the patient's perceived attractiveness of the images and their desire for surgery. To evaluate the difference the orthognathic treatment made on the outcome measures for this group of patients, mixed linear regression was used for the variable 'attractiveness of the images' and mixed logistic regression for the variable 'desire for surgery'.

3 The influence of craniofacial to standing height proportion on perceived attractiveness

3.1 Introduction

The assessment of facial beauty is essentially subjective (Peck and Peck, 1970). However, the assessment of facial proportions may be undertaken objectively. Disproportionate human faces are unattractive, whereas proportionate features are acceptable, even if not always attractive. Therefore, the appropriate goal for the surgeon's clinical examination is the detection of facial disproportions. An important proportional relationship not previously described in the surgical literature but potentially significant in planning treatment is that of the craniofacial height to standing height.

The first significant known study of human proportions was undertaken in the 5th century BC by the Greek sculptor Polycleitos of Argos. The *Canon* of Polycleitos refers to both the book written by Polycleitus, of which no copies exist, and the Roman marble copies of his original bronze statue described as the *Canon*, otherwise known as the *Doryphorus* (Spear-bearer) (Figure 3.1). Therefore, the 'ideal' human proportions suggested by Polycleitus may only be gleaned from examination of Roman copies of the Doryphorus (Naini et al., 2006).

The Roman architect Marcus Vitruvius Pollio, better known simply as Vitruvius, lived in the first century BC, and is thought to have dedicated his treatise *De Architectura* (Ten Books on Architecture) to the emperor Augustus Caesar in about 25 BC. He wrote that 'the human body is so designed by nature that the face, from the chin to the top of the forehead and the lowest roots of the hair, is a tenth part of the whole height' (Howe, 1999).

In the late 15th century the great Renaissance artist and thinker Leonardo da Vinci (1452-1519) drew the figure of *Vitruvian man* (Figure 3.2), based on guidelines described by Vitruvius, demonstrating the importance of proportions in the human form. He showed that the 'ideal' human body fitted precisely into both a circle and a square, and he thus illustrated the link that he believed existed between perfect geometric forms and the perfect body. The distance from the hairline to the inferior aspect of the chin is described as one-tenth of a man's height. The distance from the top of the head to the inferior aspect of the chin is one-eighth of a man's height (Pedretti, 2001). Albrecht Dürer (1471-1528), perhaps the most significant artist of the German Renaissance, wrote a treatise on human proportions (Dürer, 1981). The first of the *Four Books on Human Proportion*, published posthumously, described the 'ideal' man of 'Eight head-lengths' (Figure 3.3).

Farkas et al. (2005) has undertaken a large body of research throughout the 20th/21st century into the anthropometry of the human head, providing anthropometric data for adult North American Caucasian Norms. Tables 3.1 and 3.2 demonstrate the craniofacial height to standing height proportion and the vertical facial height to standing height proportion respectively, calculated from the original anthropometric data provided by Farkas (1994).

In order to find and validate the correct proportions with which to plan clinical treatment, two sources of information are required. Firstly, population averages, which permit comparison of an individuals facial measurements and proportions to the population norms. Such data must be age, gender and ethnicity specific. Secondly, the perceived attractiveness of the proportions must be confirmed by the judgement of the lay public, and ideally compared to the judgement of treating clinicians.

The purpose of this chapter is to investigate the influence of the proportion of the craniofacial height to standing height on the perceived attractiveness of the lay public and clinicians involved in the management of patients with facial deformities. The proportions considered most attractive may then be compared to the classical/neoclassical canons and modern anthropometric population norms.

Figure 3.1 The *Doryphorus* or *Spear Bearer* (Polycleitos, 5th century BC)

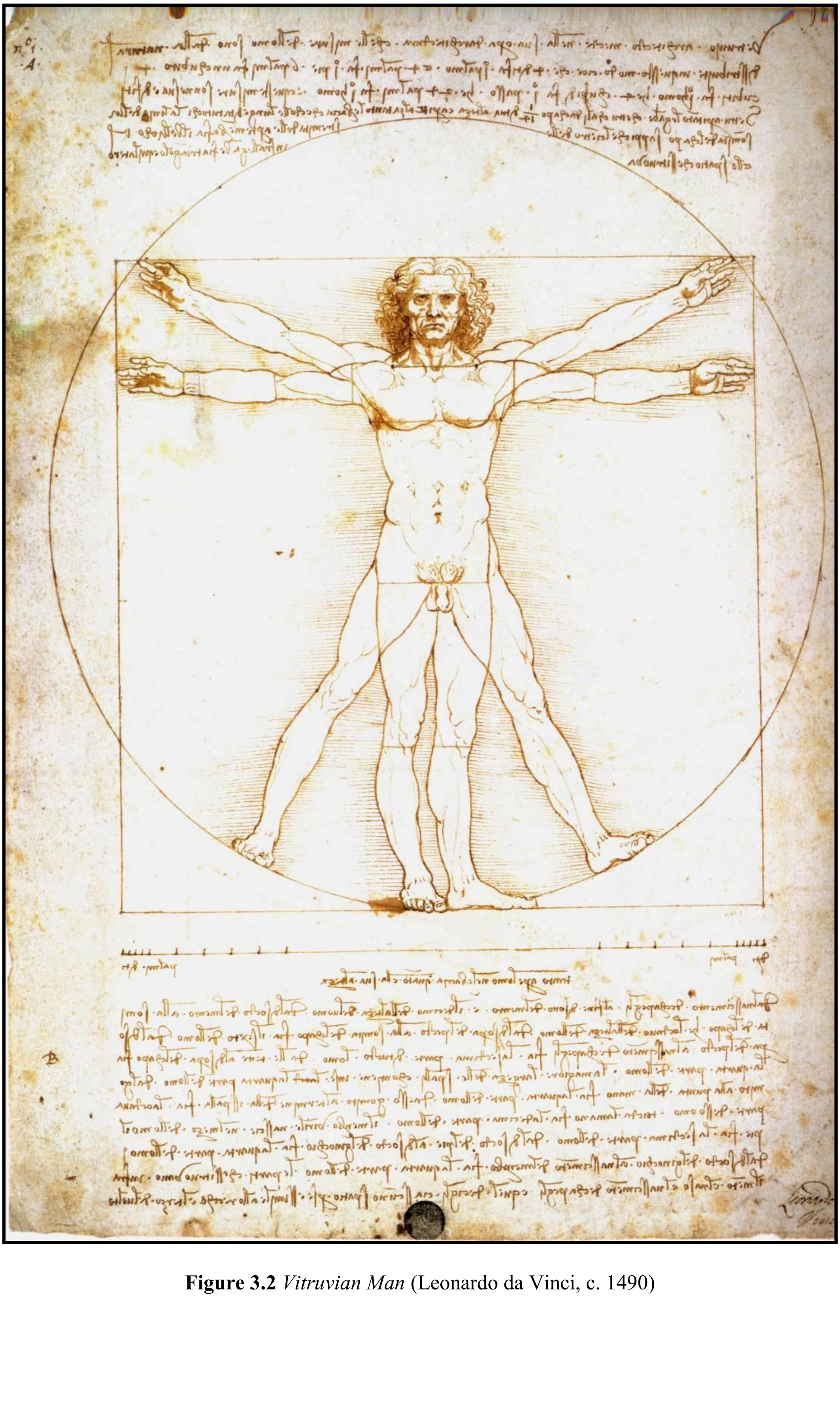

Figure 3.2 *Vitruvian Man* (Leonardo da Vinci, c. 1490)

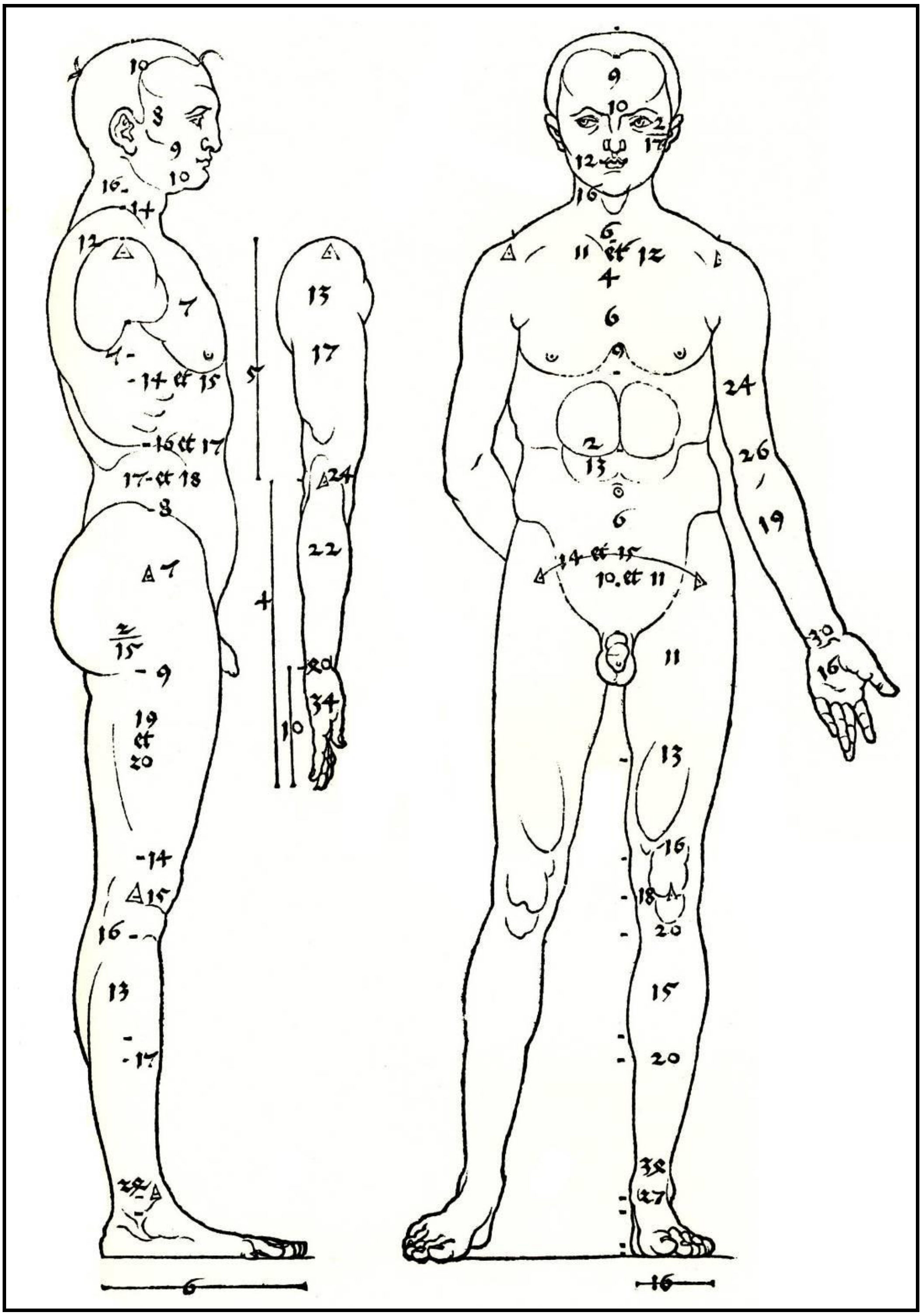

Figure 3.3 *Man of eight head-lengths* (Albrecht Dürer, c. 1528)

Table 3.1 Ratio of vertical craniofacial height (vertex-gnathion) to standing height

	Standing Height (cm)	Craniofacial Height (cm)	Average ratio of Craniofacial Height to Standing Height		
			Minimum	Mean	Maximum
Male	**176.6 (SD: 8.1)**	**22.9 (SD: 0.7)**	**7.4** 176.6-8.1/22.9	**7.7** 176.6/22.9	**8.1** 176.6+8.1/22.9
Female	**162.7 (SD: 6.9)**	**21.5 (SD: 0.8)**	**7.2** 162.7-6.9/21.5	**7.6** 162.7/21.5	**7.9** 162.7+6.9/21.5

Figures are calculated from original data by Farkas, based on adult North American Caucasian Norms (age 19-25 years) (Farkas, 1994). SD = Standard Deviation; 7.7 means the craniofacial height is 1/7.7th of standing height; vertex = the highest point on the head with the head in the Frankfort horizontal plane; gnathion = the lowest point on the lower border of the chin in the midline.

Table 3.2 Ratio of vertical face height (trichion-gnathion) to standing height

	Standing Height (cm)	Face Height (cm)	Average ratio of Face Height to Standing Height		
			Minimum	Mean	Maximum
Male	**176.6 (SD: 8.1)**	**18.7 (SD: 1.2)**	**9.0** 176.6-8.1/18.7	**9.4** 176.6/18.7	**9.9** 176.6+8.1/18.7
Female	**162.7 (SD: 6.9)**	**17.3 (SD: 0.8)**	**9.0** 162.7-6.9/17.3	**9.4** 162.7/17.3	**9.8** 162.7+6.9/17.3

Figures are calculated from original data by Farkas, based on adult North American Caucasian Norms (age 19-25 years) (Farkas, 1994). SD = Standard Deviation; trichion = the midpoint of the hairline; gnathion = the lowest point on the lower border of the chin in the midline.

3.2 Subjects and Methods

3.2.1 The Images

The image of *Vitruvian Man* (Figure 3.2) by Leonardo da Vinci was manipulated by computer software (Adobe® Photoshop® CS2 software; Adobe Systems Inc, San Jose, CA) to produce a standardised image of a man with outstretched arms. A standardised male face was drawn, with the same computer software, with 'ideal' facial proportions based on currently accepted criteria (Naini, 2011), and bilateral facial symmetry. The created face and body were pasted together. Using Photoshop image-processing software the vertical craniofacial height was digitally altered from a proportion of 1/6 of standing height to 1/10 of standing height. The proportion of the equal vertical facial thirds was maintained in all the images. Nine images were thus created with a craniofacial height to standing height proportion of 1/6, 1/6.5, 1/7, 1/7.5, 1/8, 1/8.5, 1/9, 1/9.5 and 1/10. A duplicate of one of the images was used in order to assess intra-examiner reliability (Figure 3.4).

Each of the ten images was printed onto a separate A4-size photographic paper with a matte finish. There were no other identifiable marks on the paper. Each photograph was ascribed by an exclusive symbol on its posterior surface as a code for identification when tabulating the results.

3.2.2 The observers, questionnaire and ranking method

A total of 89 observers took part in the study. These included 74 lay people (45 female; White=43; Black=11; Asian=20) and 15 clinicians (3 female; White=12; Asian=3) involved in the management of patients with facial deformities (Table 3.3). A retrospective power calculation was undertaken, using the descriptive statistics of the rank scores given to each of the images (Table 3.5), demonstrating that a total of 90 observers guaranteed 80% power to detect differences of 1.5 in the mean rank score given to a particular image, between the three ethnic groups (effect size=0.55) and between male and female observers (effect size=0.45). Each observer was provided with a questionnaire asking their age (in years), gender (male/female) and ethnicity (White, Black, Asian or Oriental). Observers undertook the ranking exercise individually. Each observer was shown the 10 photographic images, arranged in random order. The only difference between the images was the proportion of the craniofacial height to the standing height. The observers were asked to arrange the images in order from the most to the least attractive. The images were thereby ranked from the most to the least attractive.

Table 3.3 Observer age by ethnicity

Ethnicity	Mean Age (in years)	Std. Err.	95% Confidence Interval	
White	36	0.7	34.8	37.4
Black	37	1.1	35	39.6
Asian	39	1.3	36.5	41.5

3.2.3 Statistical analysis

The main outcome was the preference ranks of image attractiveness given by the 89 observers. One of the craniofacial height to standing height proportions was featured in two different images, images 8 and 9, and these constituted two replications of the measure. Bland and Altman plots and a mixed regression model were used to assess the reliability of the measure. Linear regressions were used to assess what influences the choice for the most and the least attractive images. These analyses were followed by a multivariate rank ordinal logistic regression where the independent variables were the craniofacial height to standing height proportion of the image and the age, gender, ethnicity and professional status of the observer. Data analysis was performed using the Statistical package STATA (version 9).

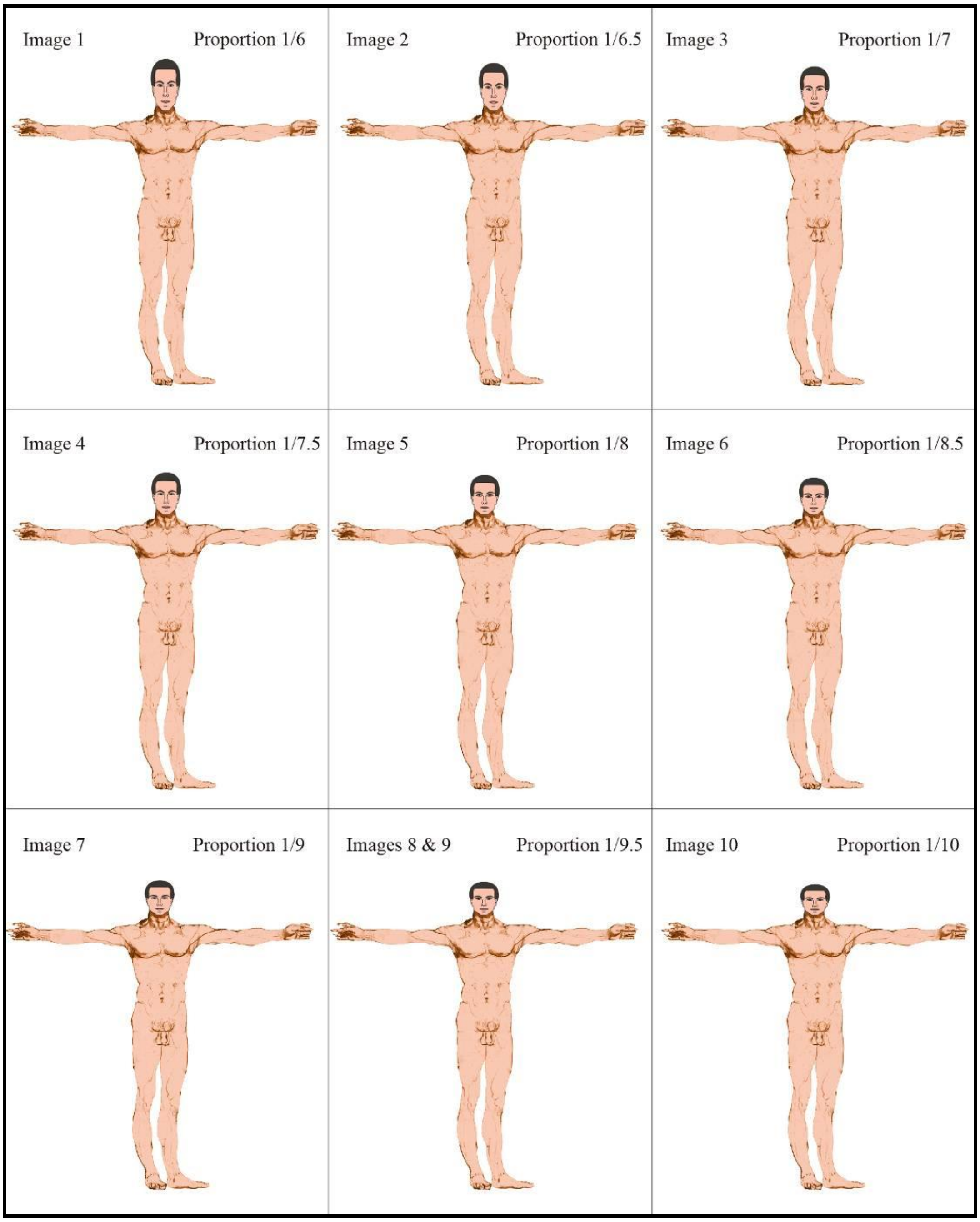

Figure 3.4 The 9 constructed images

An idealized male face was pasted together with the image of *Vitruvian Man*. Image-processing software was used to digitally alter the vertical craniofacial height from a proportion of 1/6 to 1/10 of standing height. The proportion of the equal vertical facial thirds was maintained in all the images. A duplicate of one of the images was used in order to assess intra-examiner reliability.

3.3 Results

Eighty nine observers placed each of the 10 images in rank order (most attractive = 1, least attractive = 10). Table 3.4 shows the number of rank preference scores given to all images. Table 3.5 shows the descriptive statistics of the rank preference scores by image (i.e. craniofacial height to standing height proportion).

Table 3.4 Preference scores for each image

	Rank preference scores										
	1	2	3	4	5	6	7	8	9	10	Total
Image											
1	0	0	3	0	2	15	5	2	13	49	89
2	0	1	4	8	16	6	7	24	19	4	89
3	11	9	10	21	4	4	11	14	5	0	89
4	32	26	13	3	4	2	8	0	1	0	89
5	23	36	16	7	1	6	0	0	0	0	89
6	18	12	29	15	11	2	1	1	0	0	89
7	2	1	11	17	13	13	24	5	3	0	89
8	3	1	2	9	23	11	13	13	12	2	89
9	0	2	1	4	11	27	14	20	8	2	89
10	0	1	0	5	4	3	6	10	28	32	89
	89	89	89	89	89	89	89	89	89	89	890

Table 3.5 Descriptive statistics of rank scores given to the 10 images

		Rank preference Score					
Image	**Craniofacial proportion**	**Min**	**Max**	**Mean**	**SD**	**95% Confidence Interval**	
1	6.00	3	10	8.6	1.95	*8.21*	*9.03*
2	6.50	2	10	6.9	2.04	*6.47*	*7.33*
3	7.00	1	9	4.7	2.54	*4.20*	*5.26*
4	7.50	1	9	2.6	1.97	*2.19*	*3.02*
5	8.00	1	6	2.4	1.34	*2.10*	*2.67*
6	8.50	1	8	3.0	1.51	*2.73*	*3.36*
7	9.00	1	9	5.4	1.81	*5.05*	*5.81*
8	9.50	1	10	6.2	2.05	*5.76*	*6.62*
9	9.50	2	10	6.6	1.62	*6.29*	*6.97*
10	10.00	2	10	8.5	1.87	*8.08*	*8.86*

3.3.1 *Reliability of the measure*

The Bland-Altman plot of the two replications of the score for the proportion of 1/9.5 is shown in Figure 3.5. The mixed regression model of the two scores showed that on average the difference between the two scores is 0.15 (95% confidence interval 0.01 to 0.28). This confidence interval narrowly misses zero and the P-value is very close to the 5% cut-off for non-significance. This fact, together with the intra-class correlation of 43%, indicates a moderate agreement between the two scores.

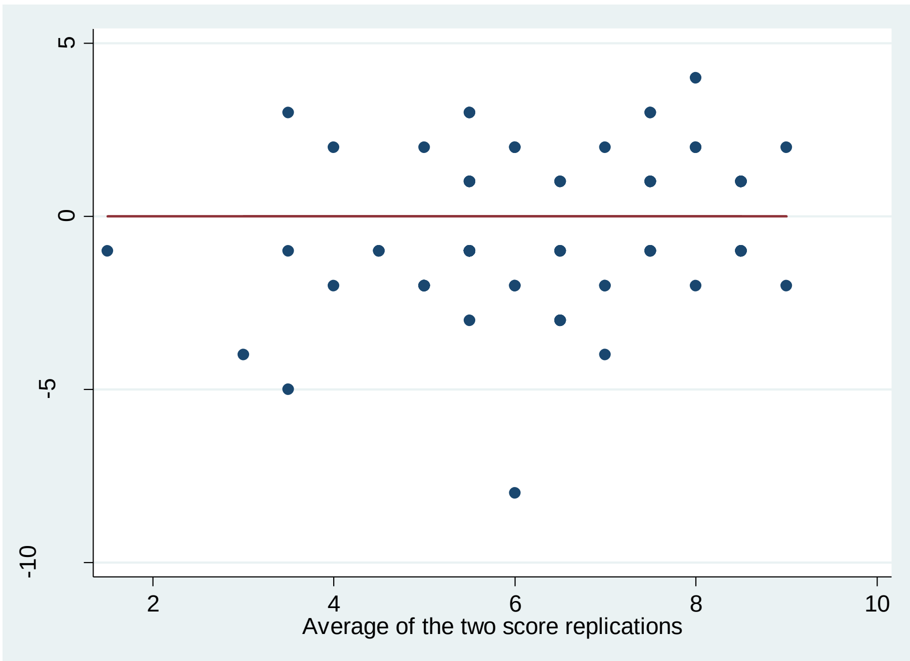

Figure 3.5 Bland and Altman plot for the two scores taken at a proportion of 1/9.5

(Difference is taken as first minus second replication)

3.3.2 *The most attractive image*

The images chosen as most attractive by more than 10% of observers were images 4, 5, 6 and 3. These images had a mean craniofacial height to standing height proportion of 1/7.8 (min=1/7 and max=1/8.5).

Image 4, with a proportion of 1/7.5, was perceived as the most attractive and received a total of 32 preference scores (36%). This was followed by image 5 (with a proportion of 1/8), which received a total of 23 preference scores (26%), image 6 (with a proportion of 1/8.5), which received a total of 18 preference scores (20%) and image 3 (with a proportion of 1/7), which received a total of 11 preference scores (12.4%). The multiple linear regression in Table 3.6 demonstrates that the choice of image 4 (with a proportion of 1/7.5), as the most attractive was not influenced by age (p=0.96), gender (P=0.23), ethnicity (P=0.19) or the professional status of the observer (P=0.23).

Images 7 and 8 received only 2.3% and 3.4% preference scores. None of the images 1, 2, 9 and 10 were ever selected as most attractive, which means that they received a preference score of zero.

3.3.3 The most unattractive image

The images that were chosen as most unattractive by more than 10% of observers were image 1 (with a proportion of 1/6) with 49 preference scores and image 10 (with a proportion of 1/10) with 32 preference scores. Images 2, 8 and 9 received only few choices as most unattractive and none of the images 3, 4, 5, 6 and 7 were ever chosen as most unattractive.

3.3.4 The effect of craniofacial height to standing height proportion on attractiveness

The multiple linear regression in Tables 3.6 and 3.7 demonstrates that neither age, gender, ethnicity nor clinical status of the observer influenced the choice for the most (image 4) or least attractive (image 1) images. The results were similar across all the images. Table 3.5 and the plots per observer shown in Figure 3.6 suggest that it is the craniofacial height to standing height proportion that determines attractiveness. The quadratic trend of the rank preference scores by craniofacial height to standing height proportion observed in the plots was confirmed by the rank ordinal logistic regression model shown in Table 3.8. The mean rank preference score is minimal for a craniofacial height to standing height proportion of 1/8 and increases when this proportion moves away from 1/8 in either direction.

Table 3.6 Multiple linear regression for the score given to the most attractive image (image 4)

Score 4	Coef.	95% Confidence Interval		P-value
Age	0.00	-0.03	0.03	0.96
Gender	-0.53	-1.41	0.35	0.23
Ethnicity	-0.58	-1.45	0.29	0.19
Professional status	-0.75	-1.97	0.48	0.23

Table 3.7 Multiple linear regression for the score given to the most unattractive image (image 1)

Score 1	Coef.	95% Confidence Interval		P-value
Age	0.01	-0.01	0.04	0.35
Gender	-0.42	-1.26	0.43	0.33
Ethnicity	0.17	-0.67	1.01	0.69
Professional status	1.17	-0.01	2.35	0.05

Table 3.8 Rank ordinal logistic regression model for score by craniofacial height to standing height proportion

Score	Coef.	95% Confidence Interval		P-value
Proportion	14.9	13.43	16.29	
Proportion ~ q	-0.92	-1.01	-0.84	0.001

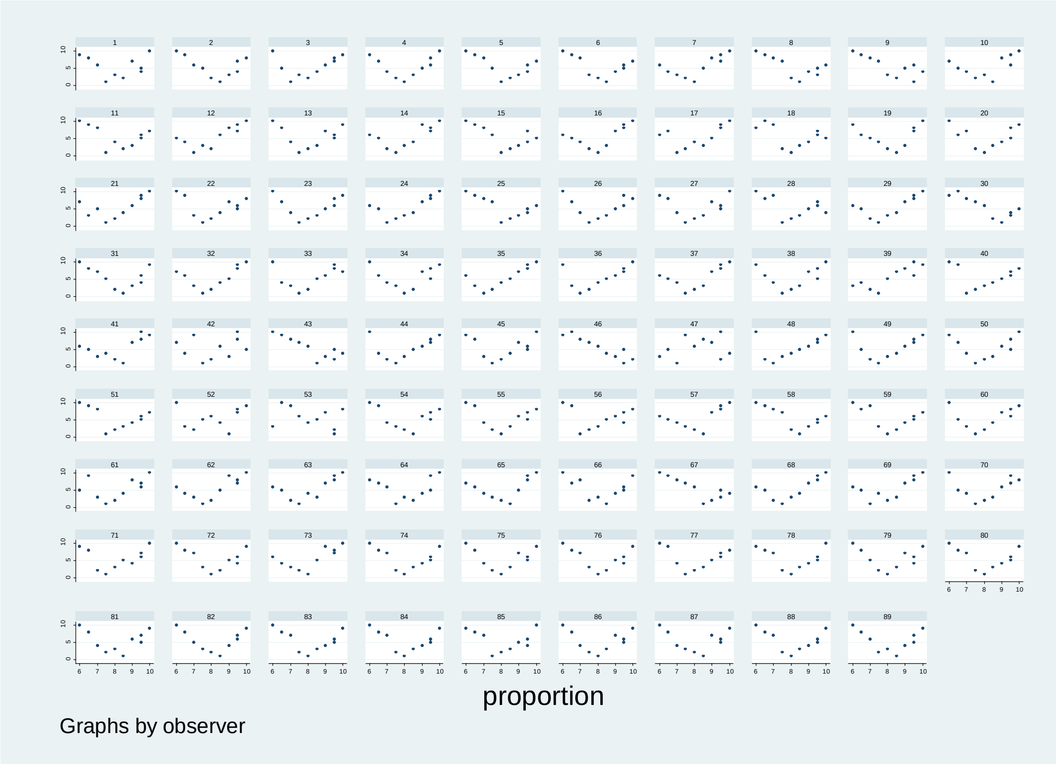

Figure 3.6 Plots of rank preference score by craniofacial height to standing height proportion, per observer

3.4 Discussion

The concept of physical beauty has been correlated with harmonious proportions throughout history. The notion is that the proportionate human face and figure is the most aesthetically pleasing. With this idea arises the question of what are ideal proportions and how does one test and validate them?

The perception of ideal proportions may vary from one individual to another, from one ethnic group to another and from one historical era to another. It is therefore vital for clinicians involved in the management of patients requiring alterations in their facial appearance to have an evidence based approach to the guidelines they employ in planning the correction of facial disproportions.

Such evidence may be obtained from two sources. Firstly, the use of anthropometric data to obtain age, gender and ethnicity specific population averages for the proportional guideline being tested; secondly, confirmation of the perceived attractiveness by the judgement of the lay public and clinicians.

3.4.1 Hypothesis testing

The first part of the null hypothesis was that ‘there is no effect of the proportion of the craniofacial height to standing height proportion on perceived attractiveness.’ We reject this null hypothesis, as the results of this study found an effect of different proportions of the craniofacial height to standing height proportion on perceived attractiveness. The second part of the null hypothesis was that ‘Likewise, there is no difference in the perception of laypeople and clinicians.’ We do not reject this null hypothesis, as no significant difference was found in the perception of laypeople and clinicians.

3.4.2 Comparison of the results with classical and neoclassical proportional canons

It is generally acknowledged that the work of Polycleitos in the 5th century BC was used by other sculptors as demonstrating the ‘ideal’ proportions of a man[7]. The craniofacial height to standing height proportion of the available marble copies of the *Doryphorus* is 1/7.5. In the late 4th century BC, the prolific sculptor Leochares is thought to have revised this canon of Polycleitos, establishing a new canon in the use of eight heads to standing height. This is evident from inspection of the Roman marble copy of the *Apollo Belvedere* in the Vatican Museum (Naini, 2011).

The Roman architect Vitruvius based his guidelines on the Classical Greek sculptors. He described the facial height to standing height proportion of 1/10, which corresponds to a craniofacial height to standing height proportion of 1/8.

However, the scientifically enquiring minds of the Renaissance were no longer interested in blindly following the Classical 'ideal', and began to study human anatomy and record human proportions. Adapting the work of Vitruvius with his own research, Leonardo da Vinci provided the neoclassical canons of proportion. He described the 'ideal' craniofacial height to standing height proportion as 1/8 (Pedretti, 2001). Dürer later described the 'ideal' man of 'Eight head-lengths' (Dürer, 1981).

The results of this study lend support to the use of a proportional ratio between the classical ideal of 1/7.5 and the Renaissance ideal of 1/8.

3.4.3 Comparison of the results with modern anthropometric data

The craniofacial height to standing height proportion may be calculated from the original anthropometric data provided by Farkas (1994). From this original anthropometric data, the craniofacial height to standing height proportion in young adult males (age range 19-25 years) was found to be 1/7.7 (range 1/7.4 to 1/8.1), and in young adult females (age range 19-25 years) was found to be 1/7.6 (range 1/7.2 to 1/7.9) (Table 3.1).

The results of this study, based on layperson and clinician judgements of attractiveness, generally validate the anthropometric data. In this study it was found that a proportion of 1/7.5 was perceived as the most attractive, with 1/8 a close second. The images regarded as most attractive by the participants had a mean craniofacial height to standing height proportion of 1/7.8 (min=1/7 and max=1/8.5). In addition, the mean rank preference score was found to be minimal for a craniofacial height to standing height proportion of 1/8 and increased when the craniofacial height to standing height proportion moved away from 1/8 in either direction (Table 3.8).

3.4.4 The influence of observer's age, gender and ethnicity on observer's perception of attractiveness

The multiple linear regression in Table 3.6 shows that choice of image 4, with a proportion of 1/7.5, as the most attractive was not influenced by the age (p=0.96), gender (P=0.23) or ethnicity (P=0.19) of the observer. These results provide support to the available evidence for the universality of judgements of attractiveness (Langlois *et al*., 2000).

3.4.5 The influence of lay or professional clinical status of observers on perception of attractiveness

The multiple linear regression in Table 3.6 shows that choice of image 4 as the most attractive was not influenced by the professional status of the observer (P=0.23).

3.4.6 Clinical implications

Patients presenting with craniofacial or dentofacial anomalies are, by definition, not average. Therefore in treatment planning, the use of mean craniofacial measurements based on population norms, though extremely important, must be used in conjunction with, and guided by a thorough understanding of facial proportional relationships.

The proportion of vertical craniofacial (head) height, and vertical facial height, to standing height has important clinical implications. If the vertical craniofacial proportions of a patient are to be altered with surgery, the treatment plan must take into account the proportion of the patient's craniofacial height to their standing height. The use of absolute numeric values of measurements rather than proportions may be misleading, as the vertical craniofacial height of a patient who is 6 feet tall will be different to that of a patient 5 feet tall.

3.5 Conclusions

The understanding of proportional relationships is vital for correct treatment planning. The important proportional relationship of the craniofacial height to standing height has not been previously described or validated in the orthodontic or surgical literature.

This study has tested the validity of the classical, neoclassical and modern anthropometric-based proportional canons for the craniofacial height to standing height proportion, and compared the results with the judgement of perceived attractiveness of the lay public and clinicians.

From the results of this study it is recommended that in planning treatment to alter any aspect of craniofacial or facial height, the ideal craniofacial height to standing height proportion of 1/7.5 to 1/8, with a range from 1/7 to 1/8.5, be considered.

4 The influence of chin height on perceived attractiveness

4.1 Introduction

The chin forms a significant aesthetic unit of the lower face. In frontal view, the significance of the chin region depends primarily on the chin height, particularly in relation to the lower and total anterior face heights (Rosen, 1995).

A facial deformity often results from a significant deviation of one or more facial parameters from the accepted norm for a population. The magnitude of the deviation is an important factor in decision-making when jaw surgery may be required. If the magnitude of the discrepancy of a facial parameter is great (for example significant increase in chin height) then the treatment planning decision may be relatively straightforward. However, there are a significant number of patients who are regarded as 'borderline' in terms of need for surgical treatment. In such patients, the decision making process may be transferred from subjective clinical judgement to objective, evidence-based guidance based on data from studies investigating perceptions of facial attractiveness (Naini et al., 2008).

Chin height is a potentially important factor in the perception of facial attractiveness. To date there have been no investigations on the perceptions of attractiveness in relation to chin height. The principle aim of this investigation was to quantitatively evaluate the influence of chin height on perceived attractiveness and to determine the clinically significant threshold value or cut-off point, beyond which a chin height discrepancy is perceived as unattractive and treatment is desired. The perception of orthognathic patients, clinicians and laypeople were also compared.

4.2 Subjects and Methods

4.2.1 The Images

Two-dimensional facial profile silhouettes have been routinely used to assess the perceptions of facial profile attractiveness. However, it is not easily possible to assess frontal facial views using silhouettes. Therefore, idealized two-dimensional frontal facial views were created using computer software.

4.2.1.1 Front face images

A male and a female frontal facial image was created with computer software (Adobe® Photoshop® CS2 software; Adobe Systems Inc, San Jose, CA). The two images were then manipulated using the same computer software to construct an 'ideal' male and an 'ideal' female symmetrical frontal facial image with proportions (Naini, 2011) and soft tissue measurements (Farkas et al., 1984; Farkas et al., 1985; Farkas et al., 1986; Farkas and Kolar, 1987; Farkas, 1994) based on currently accepted criteria as described in section 2.2.1 (see Figures 2.2 and 2.3).

4.2.1.2 Front face image manipulation (incremental)

For chin height, the images were manipulated in 2.5 mm increments, from -12.5 to 22.5 mm for the male images and from -10 to 20 mm for the female images, representing both reduction and increase in chin height (Figures 4.1 and 4.2).

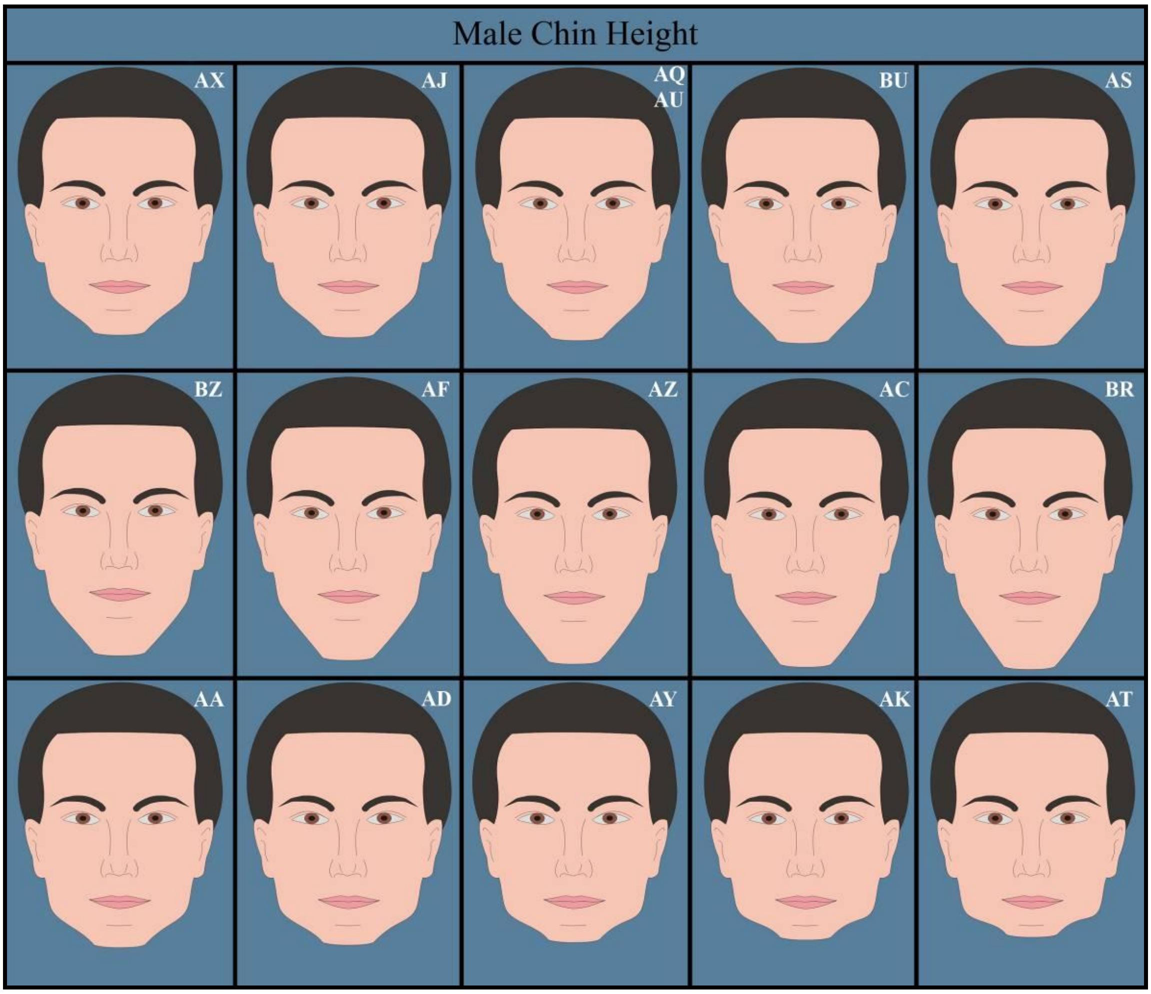

Figure 4.1 Chin height variations (male face)

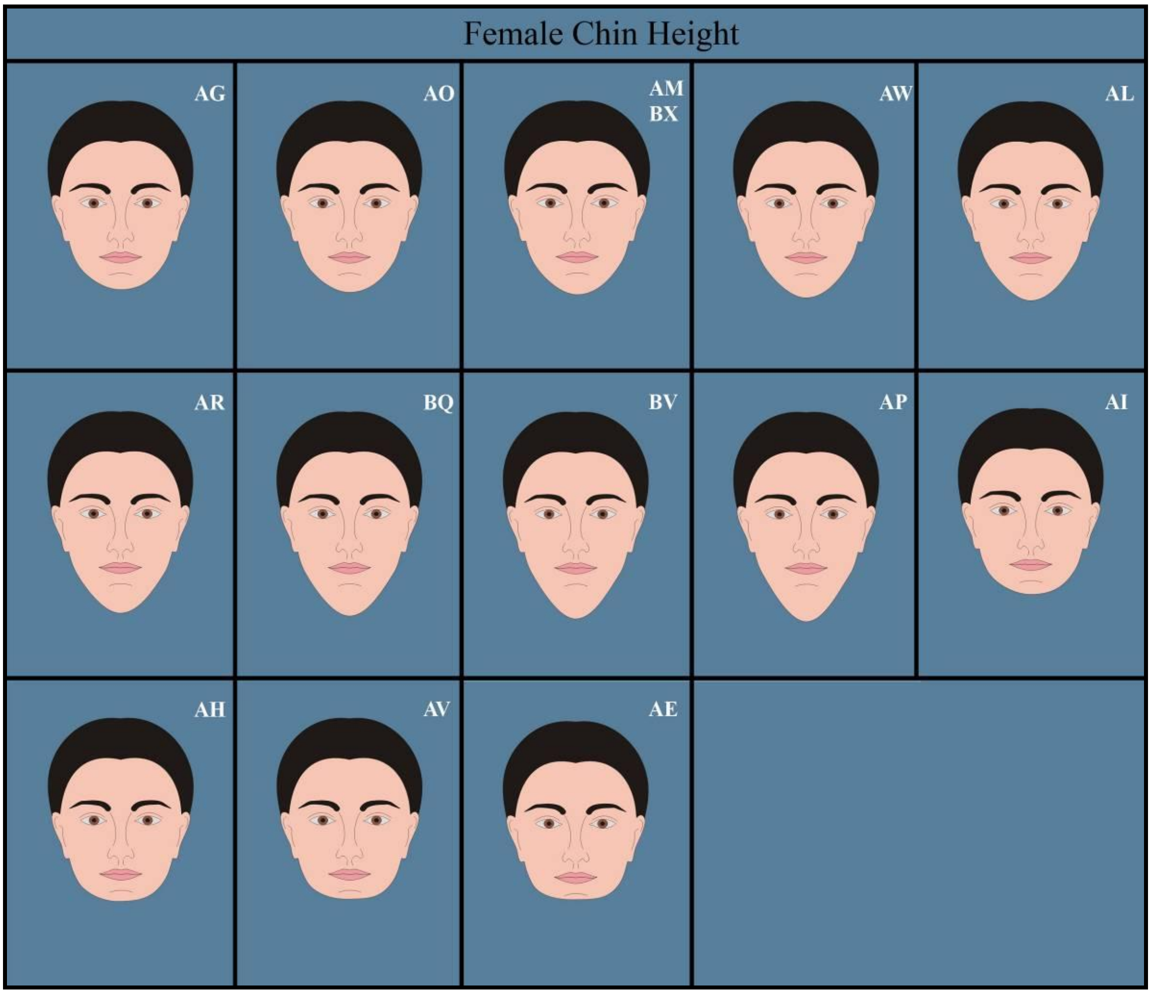

Figure 4.2 Chin height variations (female face)

4.2.2 *The observers, questionnaire and rating method*

4.2.2.1 Observers

Based on the results of the pilot study described in section 2.2.4, a total of 185 observers took part in the study, separated into 3 groups (pre-treatment orthognathic patients, laypeople and clinicians) (see Table 2.1).

Selection of the three groups of observers followed the selection criteria described in section 2.2.4.1.

4.2.2.2 Questionnaire

Each observer was given a questionnaire thanking them for agreeing to take part in the research. The observers were asked to provide the following information: age, gender, ethnic origin (White or non-White Caucasian), how would you rate the attractiveness of your facial appearance, and how important do you think it is to have an attractive facial appearance.

The observers rated each facial image using the following scale:

1. Extremely unattractive
2. Very unattractive
3. Slightly unattractive
4. Neither attractive nor unattractive
5. Slightly attractive
6. Very attractive
7. Extremely attractive

In addition, observers were asked whether they would consider surgery to correct the appearance if this was their facial appearance.

The images were placed in random order into the software application Microsoft PowerPoint®. Each image was identified by a randomly assigned double letter in the top right corner of the screen (e.g. BZ, AQ, BV etc.). A duplicate of one of the male images (images AQ and AU) and one of the female images (images AM and BX) was used in order to assess intra-examiner reliability. Each observer sat undisturbed in the same room in front of the same computer and 17” flat screen monitor. The presentation and the images were created in such a way that each of the frontal face images, when viewed on the 17” flat screen monitor, had the same dimensions as a normal human head, based around an average lower anterior facial height. This would help to reduce the potential effect of image magnification or size reduction on the observer’s perception. Each observer examined the images in the PowerPoint® presentation by pressing the 'Page Down' button on the keyboard, in their own time.

4.2.2.3 Rating method

The Likert-type rating scale is largely accepted in the psychology literature as the most useful rating method (Langlois et al., 2000). The seven-point Likert scale described above was used by each observer to rate each image in terms of attractiveness. An example of a section of the questionnaire has been provided (see Figure 2.6).

4.2.3 Statistical analysis

The observer's ratings were recorded in a Likert scale from 1 to 7. Mixed regression was used to assess the differences in ratings for the three groups (pre-treatment orthognathic patients, laypeople, and clinicians) while adjusting for the concurrent effects of age, gender, ethnicity, self-rating for facial attractiveness, the importance given to an attractive facial appearance, the observer's anteroposterior jaw relationship (Class I, II or III), the observer's vertical face height (average, increased or decreased), observer's facial asymmetry (yes/no) and the chin height of the images (reduction and increase, male and female images). The multivariate regression models were fitted in a stepwise manner, including all those variables that reached a significance below P=0.25 univariately. Given the recognised low power of the relevant test, the benchmark for a significant interaction was set at the 10% level. The mixed regression used a multi-level approach to take into account the clustering effect by observer. The model was validated using a logarithmic transformation for the rating scale to assess the effect of departure from normality.

4.3 Results

The variable 'self-rating of attractiveness' had very few observers in both its border values (very unattractive: 7 patients; very attractive: 7 laypeople) and therefore was recoded into two levels: attractive (n=123) vs. unattractive (n=62).

The variable 'vertical face height' was dichotomised into two levels: normal (n=166) vs. non-increased/decreased (n=19).

Only 11 observers responded that attractiveness was very unimportant (1 patient) or unimportant (6 patients and 4 laypeople). As a consequence this variable was dichotomised as very important vs. not very important.

There were only 17 left-handed observers in our sample.

4.3.1 Reliability analysis

A duplicate of one of the images in each section was used in order to assess intra-examiner reliability. On long one-way analysis of variance, the variability between observers, for replicated images AQ and AU (male images), was highly significant ($P<0.001$): the value of the $F(184,185)$ statistic was 3.2. These results indicate that there was not much variation in the intra-observer ratings for these images. The intra-class correlations was ICC=0.53 (95% c.i. 0.42 to 0.63), representing good reliability.

The variability between observers, for replicated images AM and BX (female images), was highly significant ($P<0.001$): the value of the $F(184,185)$ statistic was 7.2. These results indicate that there was very little variation in the intra-observer ratings for these images. The intra-class correlations was ICC=0.75 (95% c.i. 0.69 to 0.82), a very good reliability.

4.3.2 Perceived attractiveness of images

Table 4.1 shows the results of the univariate mixed linear regressions for the outcome rating. From the univariate analysis, only the observer's age, observer's gender (for female images only, p=0.02), observer's jaw relationship (skeletal Class), and the degree of chin height variation of the image (in mm) were found to have a significant effect on rating. Group differences were also observed: while no difference was detected between clinicians and patients (P=0.92), significant differences appear between laypeople and clinicians (P=0.01) and patients (P<0.001).

The direction/type of deviation (none, positive i.e. increase in chin height, or negative i.e. decrease in chin height) was found to have a highly significant association with ratings of attractiveness. The mean rating for attractiveness was greater for images with no deviation in relation to those with negative (coeff=1.65; 95% c.i. 1.5 to 1.8; P<0.001) deviation. This difference was similar for males and females faces. The mean rating for attractiveness was also greater for images with no deviation in relation to those with positive deviation but it was slightly more pronounced for male (coeff=1.70; 95% c.i. 1.5 to 1.9; P<0.001) than for female faces (coeff=1.3; 95% c.i. 1.1 to 1.5; P<0.001). The mean difference between those with positive and negative deviation was only significant for female faces (coeff=0.38; 95% c.i. 0.26 to 0.5; P<0.001), with positive deviation giving a higher rating for attractiveness.

Table 4.1 Univariate mixed linear regression for rating

	Overall		Images of male faces		Images of female faces	
Description	**Coef. – Interval**	**P value**	**Coef. - Interval**	**P value**	**Coef. - Interval**	**P value**
Age	0.02 (0.01, 0.02)	0.001	0.02 (0.01, 0.03)	0.001	0.01 (0.00, 0.02)	0.007
Gender (Male vs. female)	0.18 (-0.04, 0.40)	0.11	0.07 (-0.17, 0.31)	0.54	0.30 (0.06, 0.54)	0.02
Ethnicity (White vs. non-White)	-0.09 (-0.30, 0.13)	0.43	-0.01 (-0.25, 0.23)	0.94	-0.18 (-0.41, 0.06)	0.15
Handedness (Left vs. right)	-0.19 (-0.55, 0.18)	0.32	-0.24 (-0.64, 0.15)	0.23	-0.12 (-0.52, 0.28)	0.56
Self-rating of appearance	0.18 (-0.04, 0.41)	0.11	0.32 (0.08, 0.56)	0.01	0.02 (-0.23, 0.27)	0.88
Importance of an attractive appearance	-0.10 (-0.34, 0.13)	0.40	-0.15 (-0.40, 0.11)	0.26	-0.05 (-0.31, 0.21)	0.69
Observer's Skeletal Class (Anteroposterior jaw relationship)		0.004		0.001		0.05
II vs. I	-0.37 (-0.63, -0.11)	0.01	-0.47 (-0.75, -0.19)	0.001	-0.26 (-0.55, 0.04)	0.09
III vs. I	-0.47 (-0.75, -0.20)	0.001	-0.61 (-0.90, -0.32)	0.001	-0.32 (-0.62, -0.01)	0.04
II vs. III	0.11 (-0.22, 0.43)	0.53	0.14 (-0.21, 0.50)	0.42	0.06 (-0.31, 0.43)	0.75
Observer's Skeletal Class (II and III vs. I)	-0.42 (-0.63, -0.21)	0.001	-0.53 (-0.76, -0.31)	0.001	-0.29 (-0.52, -0.05)	0.02
Observer's vertical lower anterior face height	0.30 (-0.04, 0.65)	0.09	0.33 (-0.04, 0.71)	0.08	0.27 (-0.12, 0.65)	0.17
Amount of deviation (mm)	-0.16 (-0.16, -0.15)	0.001	-0.15 (-0.16, -0.14)	0.001	-0.17 (-0.18, -0.16)	0.001
Amount of deviation (Positives vs. 0 vs. Negatives)	0.03 (-0.02, 0.07)	0.25		0.001		0.001
Zero vs. Negatives	1.65 (1.49, 1.81)	0.001	1.62 (1.40, 1.84)	0.001	1.68 (1.46, 1.91)	0.001
Positives vs. Negatives	0.14 (0.05, 0.22)	0.001	-0.08 (-0.18, 0.03)	0.18	0.38 (0.26, 0.50)	0.001
Zero vs. Positives	1.51 (1.36, 1.66)	0.001	1.70 (1.49, 1.91)	0.001	1.31 (1.09, 1.52)	0.001
Section (Images of Male faces vs. Female faces)	-0.17 (-0.25, -0.09)	0.001				
Group		0.001		0.001		0.002
Laypeople vs. Patients	0.44 (0.21, 0.67)	0.001	0.46 (0.22, 0.71)	0.001	0.41 (0.16, 0.66)	0.001
Clinicians vs. Patients	0.29 (0.01, 0.57)	0.04	0.56 (0.26, 0.86)	0.001	-0.02 (-0.33, 0.29)	0.92
Laypeople vs. Clinicians	0.15 (-0.14, 0.43)	0.31	-0.10 (-0.40, 0.21)	0.53	0.42 (0.11, 0.74)	0.01

[Binary variables were coded as 0-1]

Table 4.2 shows the results of the multivariate mixed linear regressions for the outcome rating.

Table 4.2 Multivariate mixed linear regression for rating

	Overall		Images of male faces		Images of female faces	
Description	**Coef. – Interval**	**P value**	**Coef. - Interval**	**P value**	**Coef. - Interval**	**P value**
Age	0.01 (0.00, 0.02)	0.01	0.01 (0.00, 0.02)	0.01	0.01 (0.00, 0.02)	0.04
Gender (Male vs. female)					0.28 (0.04, 0.51)	0.02
Amount of deviation (mm)	-0.16 (-0.17, -0.15)	0.001	-0.15 (-0.16, -0.14)	0.001	-0.17 (-0.18, -0.16)	0.001
Observer Group		0.03		0.01		0.02
Laypeople vs. Patients	0.33 (0.09, 0.57)	0.01	0.34 (0.08, 0.60)	0.01	0.28 (0.02, 0.55)	0.04
Clinicians vs. Patients	0.19 (-0.10, 0.48)	0.20	0.45 (0.14, 0.76)	0.01	-0.13 (-0.45, 0.19)	0.42
Laypeople vs. Clinicians	0.14 (-0.14, 0.42)	0.33	-0.11 (-0.41, 0.19)	0.48	0.41 (0.11, 0.72)	0.01

On multivariate regression, an effect of observer's age was found (P=0.01), with older observers giving higher ratings. The mean rating for both female and male faces increased by 0.01 of a level of the Likert scale for each year older. An effect of the observer's gender was only seen for female faces with men giving on average 0.28 greater rating than women (P=0.02).

Ratings for attractiveness decrease by about 0.16 of a level of the Likert scale for every unit deviation in chin height above or below normal (P<0.001) (coeff=-0.16; 95% c.i. -0.17 to -0.14; P=0.001); this effect was similar for male and female images.

After adjusting for these effects, the mean rating was found to be significantly different between the groups with clinicians giving a greater mean rating for attractiveness than patients when assessing images of male faces (P=0.01) but not for female faces (P=0.42); laypeople giving a greater mean rating for attractiveness than patients (P=0.01) regardless of whether the images were male or female, and laypeople giving a greater mean rating for attractiveness than clinicians when looking at female faces (P=0.01) but not when looking at male faces (P=0.48).

In addition, in a separate model (not shown in table format) that fits the deviation as a categorical variable indicating levels of size 2.5mm, ratings for attractiveness decreased on average by 0.71 (95% c.i. 0.68 to 0.75) for each 2.5mm reduction in chin height, for female faces (first noticeable at -2.5mm); 0.65 (95% c.i. 0.62 to 0.68) for male faces (first noticeable at -2.5mm); 0.47 (95% c.i. 0.45 to 0.48) for each 2.5mm increase in chin height, for female faces (first noticeable at 7.5mm); 0.37 (95% c.i. 0.35 to 0.38) for male faces (first noticeable at 5mm). The pattern of change was similar for the three observer groups.

Table 4.3 Multivariate mixed linear regression for rating (orthognathic patient group)

Description	Coef. – Interval	P value
Age	0.01 (0.00, 0.02)	0.01
Amount of deviation (mm)	-0.16 (-0.16, -0.15)	0.001
Observer's Skeletal Class (Anteroposterior jaw relationship)		0.02
II vs. I	-0.29 (-0.55, -0.02)	0.04
III vs. I	-0.35 (-0.64, -0.07)	0.02
II vs. III	0.07 (-0.26, 0.39)	0.69

Including the observer’s skeletal Class in the model, considering just the group of patients, we obtain the results shown in table 4.3. The most influential variable on rating was the amount of chin height deviation. The rating was 0.16 of a level of the Likert scale less for each unit deviation in the chin height above or below normal ($P<0.001$). There were differences in the rating between skeletal Classes II and I ($P=0.02$) and between III and I ($P=0.04$). Class II and III patients gave lower ratings than Class I, but no difference was detected between Classes II and III ($P=0.69$).

4.3.3 Desire for surgery

The univariate mixed logistic regression for the binary outcome, desire for surgery, is demonstrated in table 4.4.

The multivariate mixed logistic regression for the binary outcome, desire for surgery, is demonstrated in table 4.5.

Table 4.4 Univariate mixed logistic regression for the binary outcome (desire for surgery)

	Overall		Images of male faces		Images of female faces	
Description	**OR – Interval**	**P value**	**OR - Interval**	**P value**	**OR - Interval**	**P value**
Age	0.98 (0.97, 0.99)	0.001	0.98 (0.97, 0.99)	0.001	0.99 (0.98, 1.00)	0.04
Gender (Male vs. Female)	0.71 (0.55, 0.93)	0.01	0.64 (0.47, 0.88)	0.01	0.78 (0.60, 1.00)	0.05
Ethnicity (White vs. non-White)	1.06 (0.81, 1.38)	0.68	0.98 (0.71, 1.35)	0.90	1.16 (0.90, 1.49)	0.25
Handedness (Left vs. Right)	1.03 (0.66, 1.61)	0.90	1.12 (0.66, 1.90)	0.68	0.94 (0.61, 1.44)	0.78
Self-rating of appearance	0.80 (0.61, 1.05)	0.10	0.66 (0.48, 0.91)	0.01	0.99 (0.76, 1.28)	0.92
Importance of an attractive appearance	0.99 (0.74, 1.32)	0.96	1.11 (0.78, 1.56)	0.56	0.90 (0.69, 1.19)	0.47
Observer's Skeletal Class (Anteroposterior jaw relationship)		0.04		0.01		0.33
II vs. I	1.48 (1.06, 2.05)	0.02	1.68 (1.14, 2.49)	0.01	1.26 (0.92, 1.73)	0.15
III vs. I	1.33 (0.95, 1.86)	0.10	1.56 (1.05, 2.33)	0.03	1.13 (0.82, 1.56)	0.46
II vs. III	1.11 (0.74, 1.68)	0.61	1.08 (0.66, 1.75)	0.77	1.12 (0.75, 1.66)	0.58
Observer's Skeletal Class (II and III vs. I)	1.40 (1.08, 1.82)	0.01	1.62 (1.19, 2.22)	0.002	1.20 (0.93, 1.54)	0.17
Observer's vertical lower anterior face height	1.10 (0.72, 1.69)	0.67	1.02 (0.61, 1.70)	0.95	1.17 (0.78, 1.76)	0.46
Amount of deviation (mm)	1.35 (1.32, 1.37)	0.001	1.38 (1.34, 1.41)	0.001	1.35 (1.32, 1.39)	0.001
Amount of deviation (Positives vs. 0 vs. Negatives)		0.001		0.001		0.001
Zero vs. Negatives	0.09 (0.06, 0.13)	0.001	0.05 (0.03, 0.09)	0.001	0.13 (0.08, 0.21)	0.001
Positives vs. Negatives	0.97 (0.86, 1.10)	0.67	1.20 (1.01, 1.43)	0.04	0.77 (0.64, 0.93)	0.01
Zero vs. Positives	0.09 (0.07, 0.13)	0.001	0.04 (0.02, 0.08)	0.001	0.17 (0.11, 0.27)	0.001
Section (Images of Male faces vs. Female faces)	1.05 (0.94, 1.18)	0.36				
Group		0.03		0.002		0.64
Laypeople vs. Patients	0.87 (0.65, 1.15)	0.32	0.82 (0.59, 1.15)	0.25	0.91 (0.69, 1.19)	0.48
Clinicians vs. Patients	0.63 (0.44, 0.89)	0.009	0.46 (0.30, 0.70)	0.001	0.86 (0.61, 1.21)	0.39
Laypeople vs. Clinicians	1.38 (0.97, 1.96)	0.07	1.78 (1.17, 2.70)	0.01	1.05 (0.75, 1.48)	0.77

OR, Odds Ratio

Table 4.5 Multivariate mixed logistic regression for the binary outcome (desire for surgery)

	Overall		Images of male faces		Images of female faces	
Description	**OR – Interval**	**P value**	**OR - Interval**	**P value**	**OR - Interval**	**P value**
Age	0.97 (0.96, 0.99)	0.001	0.96 (0.94, 0.98)	0.001	0.98 (0.97, 1.00)	0.05
Gender (Male vs. Female)	0.56 (0.37, 0.85)	0.006	0.46 (0.27, 0.79)	0.004	0.67 (0.45, 1.01)	0.06
Observer's vertical lower anterior face height	1.88 (0.92, 3.83)	0.08				
Amount of deviation (mm)	1.35 (1.3, 1.4)	0.001	1.37 (1.34, 1.41)	0.001	1.35 (1.32, 1.39)	0.001
Group		0.07		0.01		0.93
Laypeople vs. Patients	0.95 (0.58, 1.56)	0.83	1.17 (0.65, 2.14)	0.60	1.04 (0.66, 1.66)	0.85
Clinicians vs. Patients	0.54 (0.30, 0.97)	0.04	0.40 (0.19, 0.82)	0.01	0.94 (0.54, 1.64)	0.84
Laypeople vs. Clinicians	1.76 (1.02, 3.02)	0.04	2.95 (1.47, 5.93)	0.002	1.11 (0.65, 1.88)	0.71

OR, Odds Ratio

On multivariate logistic regression:

Observer age was found to have a significant effect on desire for surgery for both male and female faces, with the odds of desire for surgery decreasing by about 3% for each year increase in age of the observer.

The effect of observer gender was found to have a significant effect on desire for surgery and more marked for male faces than for female faces. The odds of desire for surgery were, respectively when looking at male and female faces: 54% and 33% less for male observers than for female observers.

The effect of the chin height deviation was very significant in all sections. The odds of desire for surgery increased by 35% for each unit increase or decrease in the chin height in relation to normal (OR=1.35; 95% c.i. 1.3 to 1.4; P<0.001) regardless of whether they were rating male or female faces.

After adjusting for these effects, significant differences were found between the three groups of observers for the male faces only.

The odds of desire for surgery were 60% less for clinicians than for patients when looking at male faces (P=0.01) and similar when looking at female faces (P=0.84).

The odds of desire for surgery were greater for laypeople than for clinicians, 3-fold when looking at male faces (P=0.002) but similar when looking at female faces (P=0.71).

No differences were detected between laypeople and patients (P=0.83) regardless of whether they were rating male or female faces.

Comparison of skeletal Classes I, II and III in the orthognathic patient group is demonstrated in table 4.6.

Table 4.6 Multivariate mixed logistic regression for binary outcome for male and female images (desire for surgery) (orthognathic patient group)

Description	OR – Interval	P value
Age	0.98 (0.96, 0.99)	0.01
Gender (Male vs. Female)	0.57 (0.38, 0.87)	0.01
Observer's vertical lower anterior face height	2.08 (1.02, 4.22)	0.04
Amount of deviation (mm)	1.35 (1.32, 1.37)	0.001
Observer's Skeletal Class (Anteroposterior jaw relationship)		0.15
II vs. I	1.68 (0.97, 2.91)	0.06
III vs. I	1.43 (0.80, 2.55)	0.23
II vs. III	1.18 (0.62, 2.22)	0.62

OR, Odds Ratio

A multivariate logistic regression including the observer’s skeletal Class fitted to the group of patients showed no significant differences between the three skeletal Classes (P=0.15), although the odds of desire for surgery tended to be 68% greater for skeletal Classes II (P=0.06) and 43% for skeletal Class III (P=0.23) in relation to skeletal Class I. No difference was detected between skeletal Classes II and III (P=0.62).

The linear values (in mm) at which observers begin considering surgery are shown in table 4.7. The proportional values, in terms of percentage of lower anterior face height, at which observers first noticed and also began considering surgery are shown in table 4.8.

Table 4.7 Values at which desire for surgery becomes significant

Type of chin height discrepancy	Values at which desire for surgery becomes significant (mm)					
	Patients		Laypeople		Clinicians	
	Male images	Female images	Male images	Female images	Male images	Female images
Increase	10.2	10.7	10.9	10.9	14.4	11.3
Reduction	7.2	5	8	6.02	9.1	5.8

Table 4.8 The values (proportional) at which observers first notice and also begin considering surgery

	Male images (% of LAFH)				Female images (% of LAFH)			
	Chin height increase first noticed	Surgery desired (increase in chin height)	Chin height decrease first noticed	Surgery desired (decrease in chin height)	Chin height increase first noticed	Surgery desired (increase in chin height)	Chin height decrease first noticed	Surgery desired (decrease in chin height)
Patients	40.5	49	30	23	50	58	28	22
Laypeople	40.5	49	30	22	50	58	28	20
Clinicians	40.5	54	30	20	50	58	28	20

LAFH: Lower anterior face height; 'Ideal' value for chin height is 33.3% in relation to LAFH

4.3.4 Most attractive and least attractive images

Table 4.9 shows that the lowest rated images, AP, AE, AT, AZ, AC and BR, represented significant degrees of chin height variation from the 'norm'. The highest rated images, AO, AX, BX, AJ, AG and AM, represented the 'norm' or slight increases of up to 5 mm. The overall trend demonstrates that milder degrees of chin height variation, e.g. 5 mm, were rated higher, and greater degrees of variation were rated progressively lower and thereby less attractive.

Table 4.9 Mean observer ratings and confidence intervals, ordered from worse to best rating

Image	Chin height (mm)	Mean	95% Confidence Interval		Median
AP	20f	2.11	1.98	2.24	2
AE	-10f	2.11	1.96	2.26	2
AT	-12.5m	2.21	2.07	2.35	2
AZ	17.5m	2.23	2.08	2.38	2
AC	20m	2.24	2.10	2.39	2
BR	22.5m	2.27	2.10	2.44	2
BV	17.5f	2.28	2.13	2.42	2
AK	-10m	2.50	2.34	2.66	2
AF	15m	2.56	2.39	2.73	2
BQ	15f	2.61	2.46	2.75	3
AR	12.5f	2.90	2.74	3.05	3
AY	-7.5m	2.98	2.82	3.13	3
AV	-7.5f	3.08	2.93	3.23	3
BZ	12.5m	3.15	2.98	3.32	3
AS	10m	3.40	3.20	3.59	3
AH	-5f	3.48	3.30	3.66	3
AL	10f	3.56	3.35	3.77	3
BU	7.5m	3.92	3.72	4.12	4
AU	5m	4.26	4.04	4.47	4
AW	7.5f	4.34	4.16	4.52	4
AI	-2.5f	4.48	4.30	4.67	4
AQ	5m	4.50	4.29	4.71	5
AD	-5m	4.67	4.49	4.85	5
AA	-2.5m	4.77	4.60	4.95	5
AM	5f	4.85	4.65	5.05	5
AG	0f	4.97	4.80	5.14	5
AJ	2.5m	4.99	4.80	5.18	5
BX	5f	5.01	4.82	5.19	5
AX	0m	5.05	4.86	5.23	5
AO	2.5f	5.35	5.18	5.52	5

Positive values represent increases and negative values represent reductions in chin height; m = male; f = female)

4.4 Discussion

Physical attractiveness is recognized as an important attribute in psychosocial well-being. The lower third of the face in particular is a source of concern for some individuals, being a focal point in social interaction as well as the source of verbal and much non-verbal communication.

A large number of studies have been undertaken to assess psychological factors involved in perceptions of facial attractiveness (Langlois et al., 2000). However, the present investigation was concerned with perceptions of attractiveness for chin height, seeking objective evidence to guide clinicians involved in the treatment planning of patients with chin height deformities.

In order to determine and validate the correct facial proportions to plan clinical treatment, two sources of information are required (Naini et al., 2008). Firstly, population averages, which permit comparison of an individual's facial measurements and proportions to the population norms. Such data must be age, gender and ethnicity specific and are available from anthropometric (Farkas and Cheung, 1981) and long term cephalometric growth studies of normal individuals (Broadbent et al., 1975; Cortella et al., 1997). Secondly, the perceived attractiveness of the proportions must be confirmed by the judgement of patients and the lay public, and ideally compared to the judgement of treating clinicians. This was the main purpose of this investigation.

4.4.1 Hypothesis testing

The first part of the null hypothesis was that 'there is no effect of the type or degree/severity of the deviation of chin height on perceived attractiveness and desire for surgery.' We reject this null hypothesis, as the results of this study found an effect of the type and degree/severity of the deviation of chin height on both perceived attractiveness and desire for surgery. The second part of the null hypothesis was that 'Likewise, there is no difference in the perception of orthognathic patients, laypeople and clinicians.' We reject this null hypothesis, as the results of this study found a difference in the perceptions of the observer groups.

4.4.2 Influence of the degree of chin height discrepancy of the image

Ratings for attractiveness decrease by about 0.16 of a level of the Likert scale for every unit deviation in chin height above or below normal; this effect was similar for male and female images.

Discrepancy in chin height was noticed when it was at least 5mm taller in male faces or 7.5 mm taller in female faces, or -2.5mm shorter (male or female faces) than normal. Therefore, between -2.5 mm and 5 mm (7.5 mm female) chin height discrepancies are largely unnoticed. Results were similar for the three groups of observers. However, the ratings decreased more rapidly for reductions in chin height. For example, with -7.5 mm shorter chin height than normal the rating was reduced by 2 levels of the Likert scale, whereas only at 12.5 or 15 mm taller chin height than normal did the Likert scale decrease by 2 levels.

4.4.3 At what degree of chin height discrepancy does the discrepancy become so noticeable that patients want (or clinicians or laypeople recommend) surgical correction?

There is some variation in the values at which observers begin considering surgery. When the chin height discrepancy is taller than normal, patients begin to consider surgery at 10.5 mm (female images 10.7, male images 10.2), laypeople at 10.9 mm (male and female images), and clinicians at 13 mm (11.3 for female images, 14.4 for male images).

When the chin height discrepancy is shorter than normal patients begin to consider surgery at -6.2 mm (female images -5.0, male images -7.2), laypeople at -7.2 mm (female images -6.02, male images -8.0), and clinicians at -7.6mm (female images -5.8, male images -9.1).

4.4.4 Influence of observer group and professional status

The results for both outcomes (perceived attractiveness and desire for surgery) indicate that pre-treatment orthognathic patients and clinicians are more critical than laypersons. However, no significant differences were found between the clinicians and patients, except for ratings of male images (p=0.01) (Table 4.2) and for desire for surgery overall and for male images (p=0.01) (Table 4.5). Clinicians will develop enhanced critical faculties as a result of their training and it may be that the very existence of a chin height discrepancy will lead to patients developing a greater sensitivity to noticeable differences in facial appearance from the 'ideal'. Previous studies have found significant differences between the perceptions of facial profile attractiveness of orthodontists and maxillofacial surgeons compared with laypeople (Cochrane et al., 1999). Attractiveness studies often use laypeople as observer's but seldom use patients. The finding that orthognathic patients are more critical than laypersons, suggests that in future studies, greater emphasis might be put on evaluating the perceptions of patients as opposed to a lay population.

4.4.5 Desire for surgery

The odds of wanting surgery reduced with increases in age of the observers, with a reduction of about 3% for each year increase in age. The reasons for this may be manifold, including a potentially greater preoccupation with facial appearance at a younger age and possibly more stability in lifestyle in older individuals. The effect of observer gender was found to have a significant effect on desire for surgery and more marked for male faces than for female faces. The odds of desire for surgery were, respectively when looking at male and female faces: 54% and 33% less for male observers than for female observers. No variation was noted between Whites with respect to non-White observers.

The effect of chin height deviation was very significant in all sections. The odds of desire for surgery increased by 35% for each unit increase or decrease in the chin height in relation to normal regardless of whether the observers were rating male or female faces.

Significant differences were found between the three groups of observers. The odds of desire for surgery were 60% less for clinicians than for patients when looking at male faces and similar when looking at female faces, greater for laypeople than for clinicians, 3-fold when looking at male faces but similar when looking at female faces. Interestingly, no differences were detected between laypeople and patients regardless of whether they were rating male or female faces.

The orthognathic patient group showed no significant differences between the three skeletal Classes I, II or III, although the odds of desire for surgery tended to be 68% greater for skeletal Classes II and 43% for skeletal Class III in relation to skeletal Class I. No difference was detected between skeletal Classes II and III.

4.4.6 Most attractive and least attractive images

The lowest rated images, AP, AE, AT, AZ, AC and BR, represented significant degrees of chin height variation from the ‘norm’. The highest rated images, AO, AX, BX, AJ, AG and AM, represented the ‘norm’ or slight increases of up to 5 mm. The overall trend demonstrated that milder degrees of chin height variation, i.e. up to 5 mm, were rated higher, and greater degrees of variation were rated progressively lower and thereby less attractive.

4.4.7 Proportional relationships

The proportional relationships used in clinical practice are based on a combination of classical canons, and modern anthropometric and cephalometric population studies (Naini, 2011).

Leonardo da Vinci (c. 1490) subdivided the lower anterior face height (LAFH) into thirds, with the upper lip height $1/3^{rd}$ and the lower lip and chin height as $2/3^{rds}$. The lower lip-chin height was further divided into the lower lip height ($1/3^{rd}$) and the chin height ($2/3^{rds}$) (Naini, 2011). The proportional relationship of $1/3^{rd}$ and $2/3^{rds}$ was subsequently confirmed in contemporary cephalometric studies by Worms et al. (1976) and Legan and Burstone (1980); however, both found that the greater part of the lower facial height was occupied by the chin height and the smallest by the lower lip height, in both males and females. Albrecht Dürer (1528) subdivided the lower anterior face height into quarters, with the upper lip and lower lip heights each 25% and chin height 50% of lower anterior facial height (Naini, 2011).

In a cephalometric study of 56 “normal White adults” with Class I dental and skeletal relationships, Scheideman et al. (1980) found the LAFH greater than the middle anterior face height in men, mainly due to a greater lower lip/chin height. They also found that upper lip height was 32% (31% in females), lower lip height 25% (27% in females), chin height 43% (40% in females) and lower lip-chin height 68% (67% in females) of LAFH. In an anthropometric study of White adults, Farkas et al. (1984) found that upper lip height was 31%, lower lip height 26%, chin height 43% and lower lip-chin height 69% of LAFH in males and females.

Mommaerts and Moerenhout (2011) asked 20 patients who had to undergo ‘orthofacial’ surgery to rank the images of ‘beautiful faces’ retrieved from yearly polls of magazines. They concluded that a proportional canon of upper lip height as 30% and lower lip-chin height as 70% of LAFH, as the contemporary ideal. This supports the previous results of Scheideman et al. (1980) and Farkas et al. (1984).

The results of this current attractiveness study demonstrate that the classical lower facial proportional canon of upper lip height as $1/3^{rd}$ (33.3%), lower lip height as $1/3^{rd}$ (33.3%) and chin height as $1/3^{rd}$ (33.3%) of lower anterior face height may be used as an ‘ideal’ proportional ratio. This supports previous evidence from anthropometric and cephalometric population studies (Worms et al., 1976; Legan and Burstone, 1980; Scheideman et al., 1980; Farkas et al., 1984). However, the results also demonstrate that chin height variations within a given proportional range are largely unnoticed, i.e. between approximately 30% chin height in relation to LAFH (male and female), up to approximately 40% (males) and 50% (females) chin height in relation to LAFH. Additionally, surgery is only desired with greater variations in chin height, i.e. male images with chin height greater than ~50% and less than 20-23% of LAFH, and female images with chin height greater than 58% and less than 20-22% of LAFH.

There is variation in the proportional canons and individual variability in the results of modern studies; this demonstrates that such relationships are a useful first step in the clinical evaluation of lower facial proportions, but only as guidelines. Ultimately, each patient must be evaluated as an individual.

4.5 Conclusions

In relation to the classical lower facial proportional canon, surgical correction of chin height deformities are desired with chin height greater than 50% and less than 20-23% of LAFH in males, and greater than 58% and less than 20-22% of LAFH in females.

Such proportional standards from attractiveness perception studies provide potentially useful data for diagnosis and treatment planning of corrective surgery of vertical chin height deformities.

5 The influence of asymmetry affecting the mandible and chin point on perceived attractiveness

5.1 Introduction

Symmetry is defined as a correspondence in the size, shape and relative position of parts on opposite sides of a dividing line or median plane (Naini, 2011). Asymmetry is described as a lack or absence of symmetry. The application of this definition to the human face illustrates an imbalance or disproportionality between the right and left sides. Although a mild degree of asymmetry is normal and acceptable in the average face, greater degrees of asymmetry have been correlated with clinical depression, low self-esteem and other health problems associated with poor quality of life, such as neurosis and inferiority complex (Shackelford and Larsen, 1997). A number of studies have demonstrated that facial asymmetry can have a significant influence on perceived attractiveness (Rhodes et al., 1998; Perrett et al., 1999).

Facial asymmetry can be caused by a range of factors that affect the underlying facial skeleton and/or the overlying soft tissues. Asymmetry of the lower third of the face often results from asymmetric growth of the mandible, which may be predominantly horizontal (hemimandibular elongation) or predominantly vertical (hemimandibular hyperplasia) in direction, or a combination of the two (Obwegeser and Makek, 1986).

Each facial parameter, such as lower facial symmetry, will have an ‘average’ value or ‘norm’ for a given population, which is specific for age, gender and ethnicity. Each of these ‘norms’ will also have a range of variability, with the existence of a facial deformity often resulting from a significant deviation of one or more facial parameters from the accepted norm for a population. At what point does the deviation of a facial parameter move from the limits of the acceptable range of variability into being perceived as a facial deformity?

The magnitude of the deviation, irrespective of whether it is due to an underlying dento-skeletal discrepancy, the overlying facial soft tissues or a combination of the two, is an important factor in decision-making when jaw surgery may be required. If the magnitude of the discrepancy of a facial parameter is great (for example significant mandibular asymmetry) then the treatment planning decision may be relatively straightforward. However, there are a significant number of patients who are regarded as ‘borderline’ in terms of need for surgical treatment. In such patients, the decision making process may be transferred from subjective clinical judgement to objective, evidence-based guidance based on data from studies investigating perceptions of facial attractiveness. For example, if the relative position or size of a facial parameter, such as chin asymmetry, is being assessed, it may be found that a large percentage of observers find that greater than *x* mm of chin asymmetry from the facial midline is regarded as unattractive and requiring surgical correction. This would provide objective evidence to guide clinicians when planning treatment.

Mandibular and chin point asymmetry are potentially important factors in the perception of facial attractiveness. To date there have been no investigations on the perceptions of attractiveness in relation to mandibular and chin point asymmetry. Therefore, no objective evidence currently exists to help clinicians in planning the treatment of patients with these types of facial deformity, in relation to the influence of severity on perceived attractiveness.

The principle aim of this investigation was to quantitatively evaluate the influence of mandibular and chin point asymmetry on perceived attractiveness. In addition, the relationship between degree of asymmetry and attractiveness was recorded to ascertain the range of normal variability, in terms of observer acceptance and determine the clinically significant threshold value or cut-off point, beyond which a mandibular and chin point asymmetry is perceived as unattractive and treatment is desired. Finally, the perception of orthognathic patients, clinicians and laypeople were compared for these different variables.

5.2 Subjects and Methods

5.2.1 The Images

Two-dimensional facial profile silhouettes have been routinely used to assess the perceptions of facial profile attractiveness. However, it is not possible to assess frontal facial views using silhouettes. Therefore, idealized two-dimensional frontal facial views were created using computer software.

5.2.1.1 Front face images

A male and a female frontal facial image was created with computer software (Adobe® Photoshop® CS2 software; Adobe Systems Inc, San Jose, CA). The two images were then manipulated using the same computer software to construct an 'ideal' male and an 'ideal' female symmetrical frontal facial image with proportions (Naini, 2011) and soft tissue measurements (Farkas et al., 1984; Farkas et al., 1985; Farkas et al., 1986; Farkas and Kolar, 1987; Farkas, 1994; Naini, 2011) based on currently accepted criteria as described in section 2.2.1 (see Figures 2.2 and 2.3).

5.2.1.2 Front face image manipulation (incremental)

For mandibular and chin point asymmetry, the male and the female images were manipulated, to the left and the right, in 5 mm increments from 0 to 25 mm, in horizontal (corresponding to the mandibular and chin point asymmetry viewed in hemimandibular elongation), vertical (corresponding to the asymmetry viewed in hemimandibular hyperplasia) and combined horizontal and vertical directions (Figures 5.1 to 5.6).

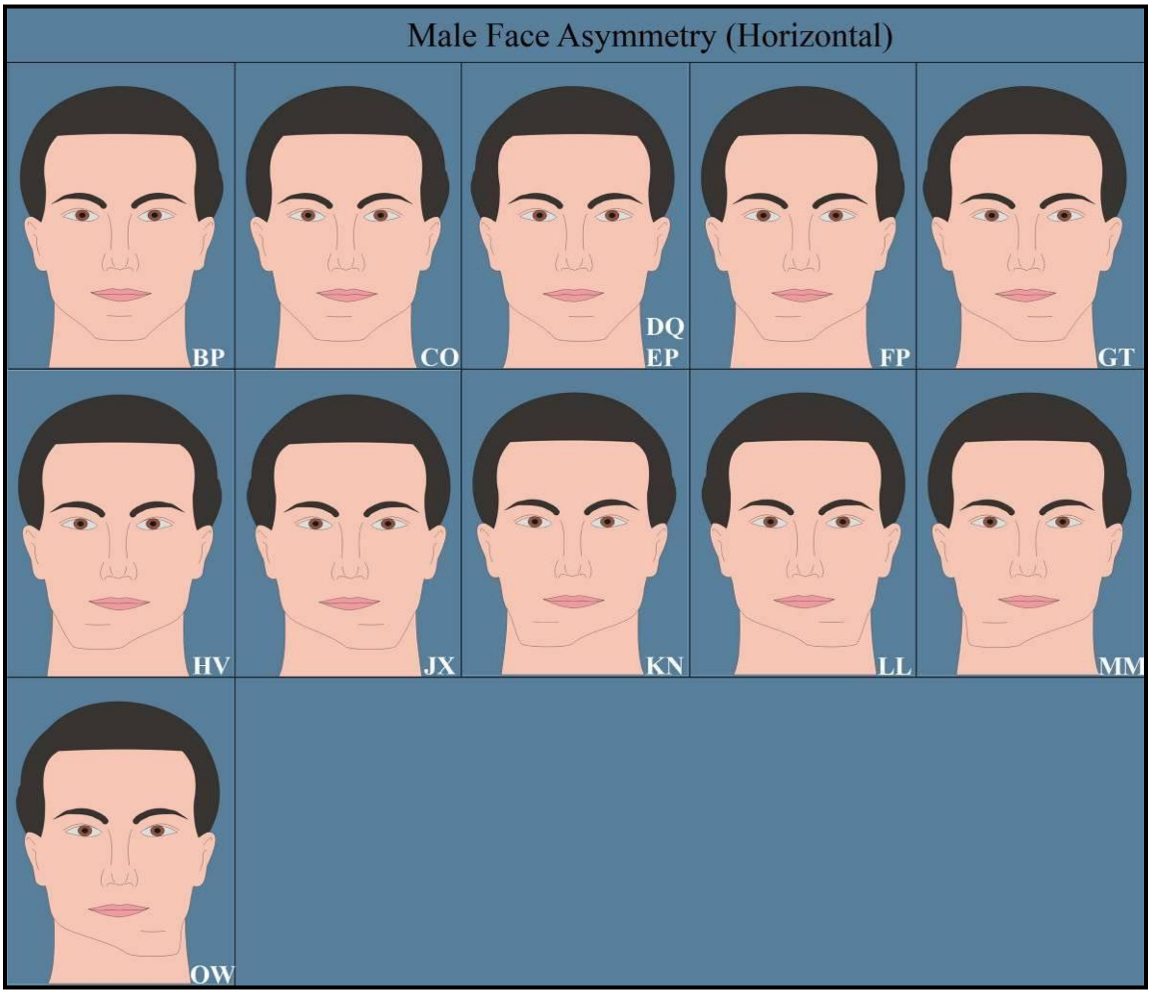

Figure 5.1 Horizontal mandibular and chin point asymmetry (male face)

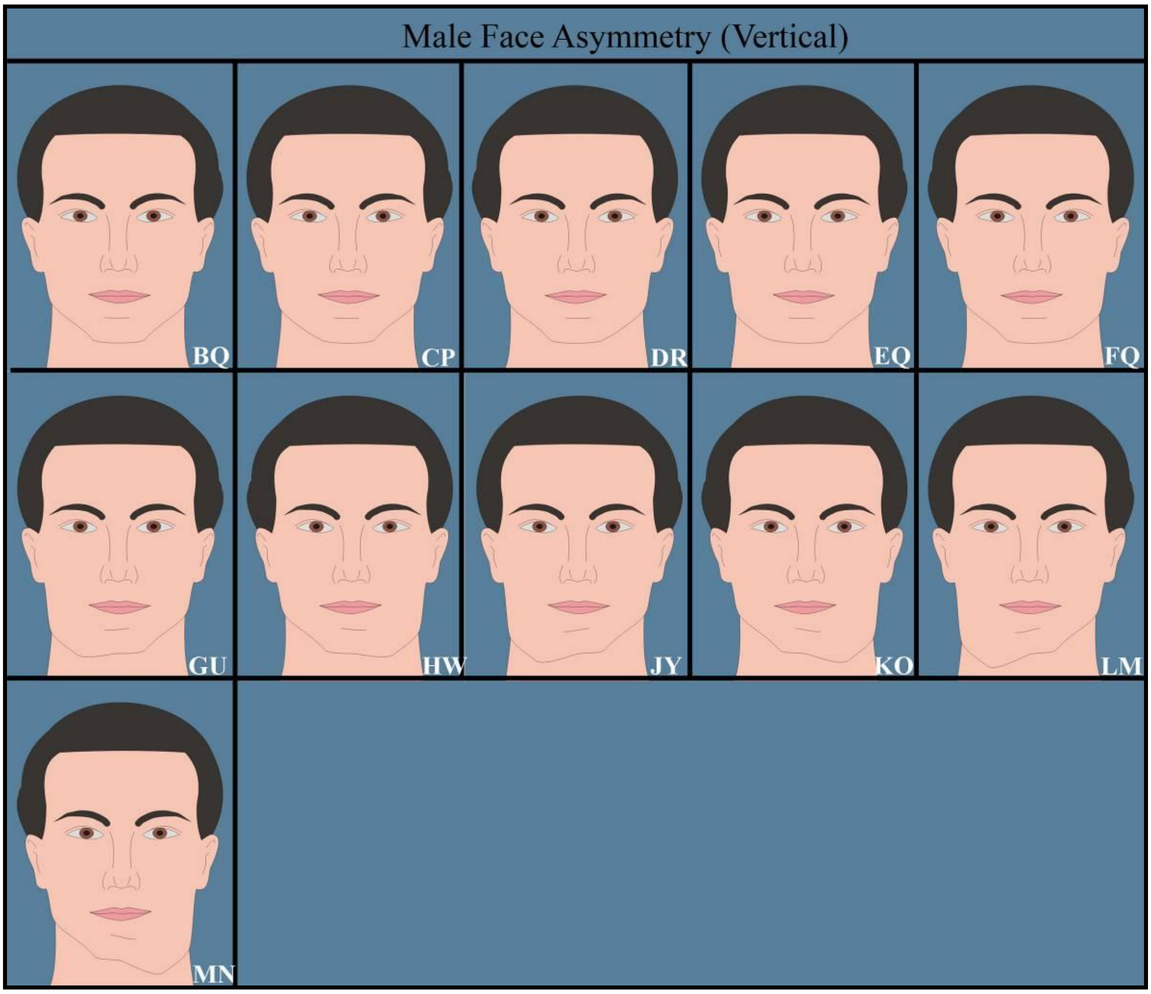

Figure 5.2 Vertical mandibular and chin asymmetry (male face)

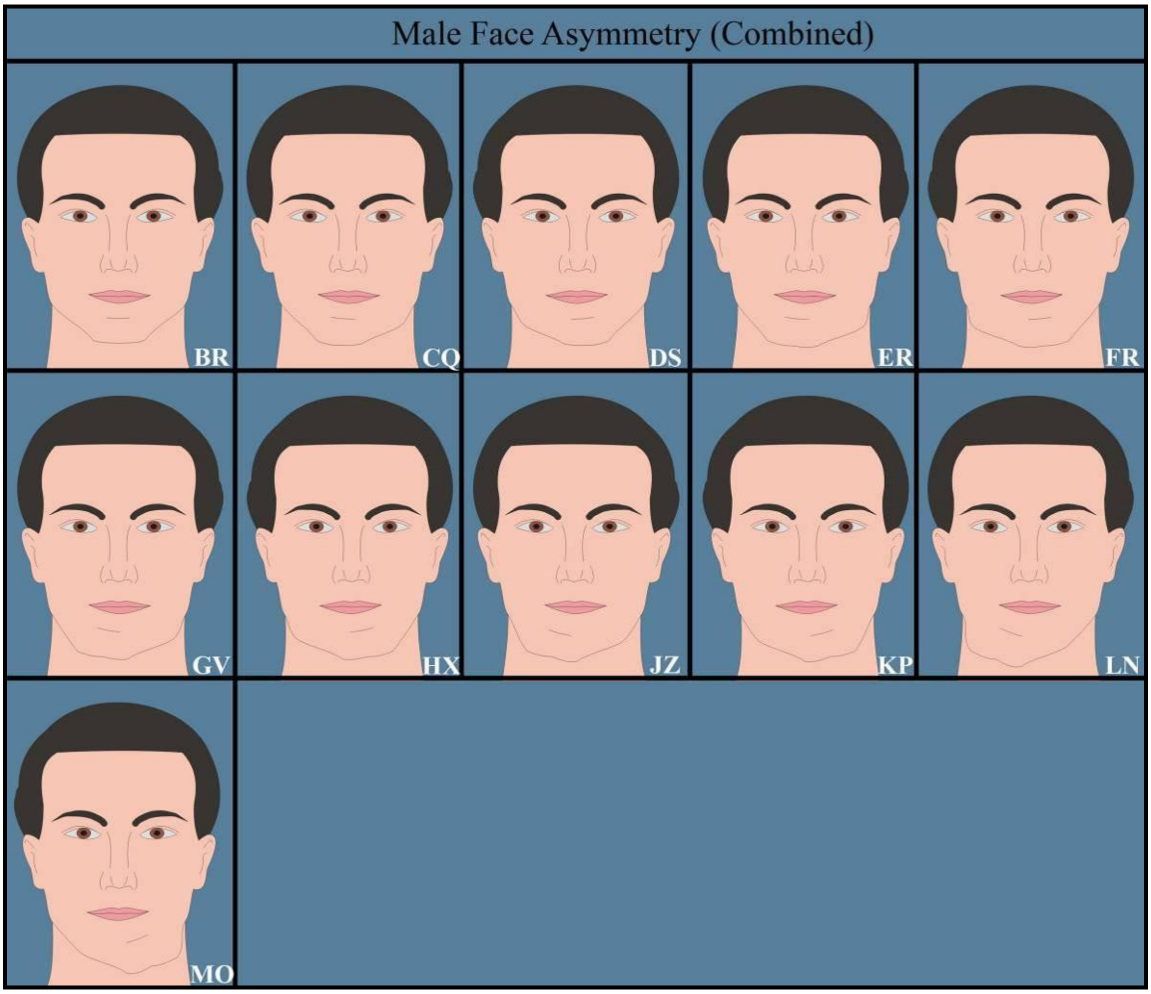

Figure 5.3 Combined mandibular and chin point asymmetry (male face)

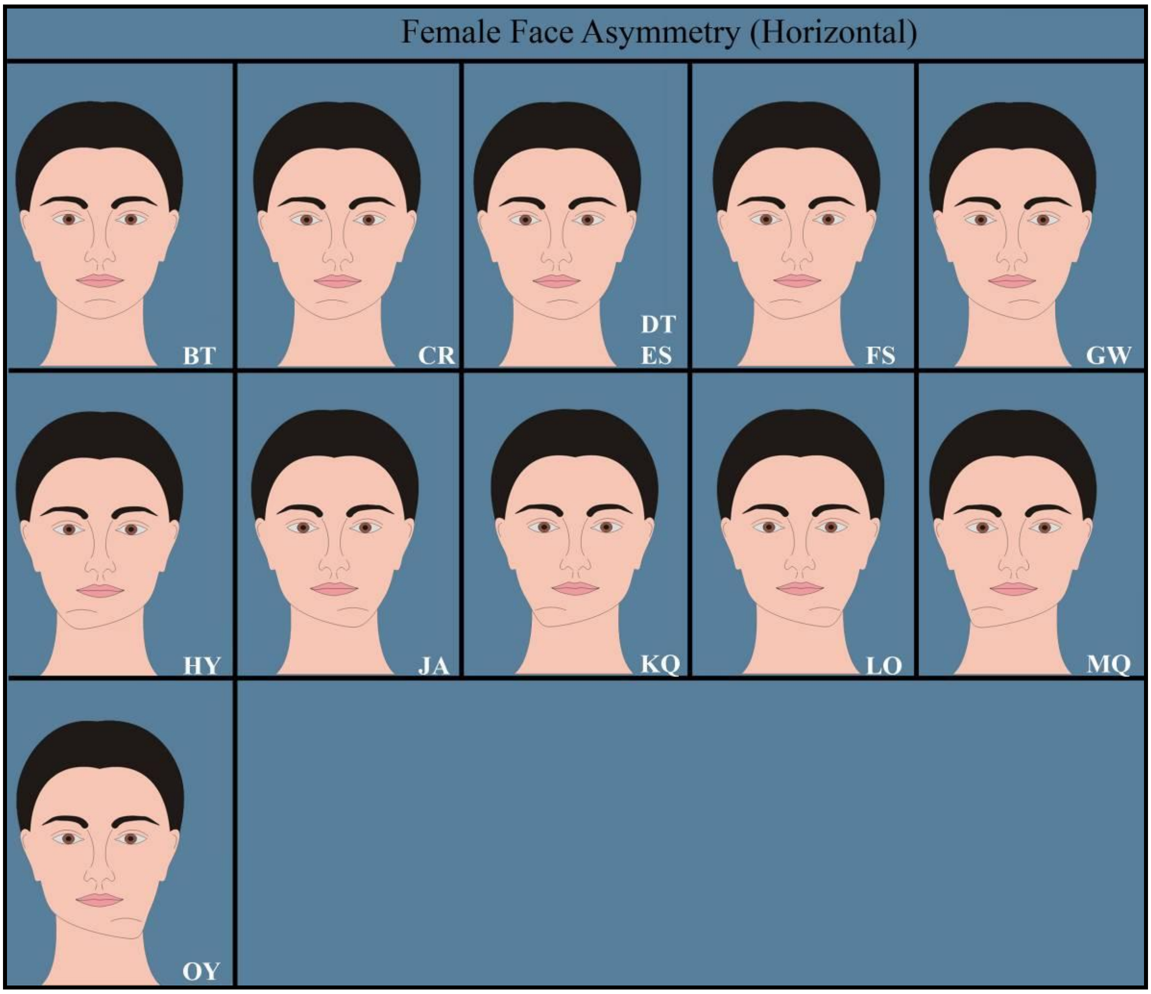

Figure 5.4 Horizontal mandibular and chin point asymmetry (female face)

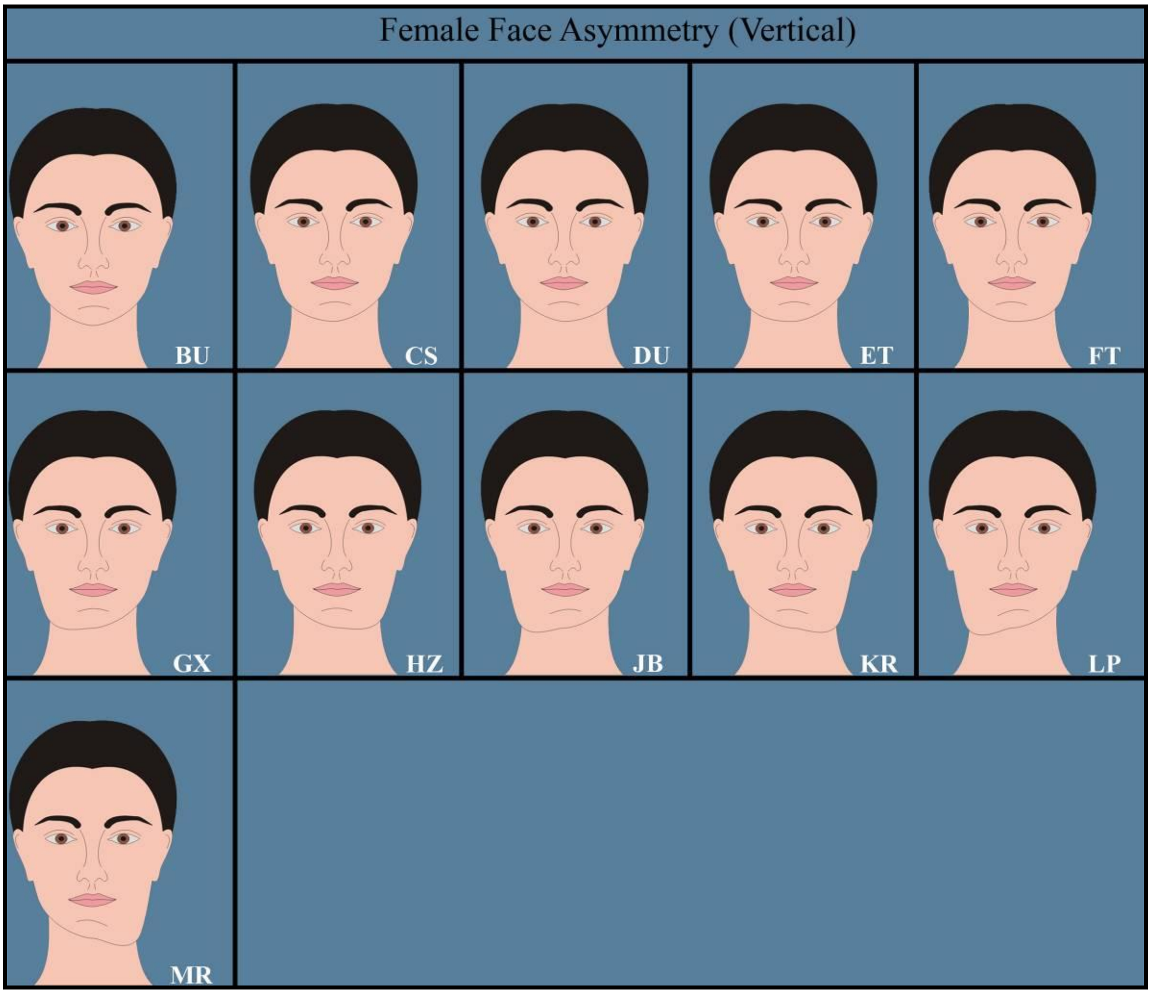

Figure 5.5 Vertical mandibular and chin asymmetry (female face)

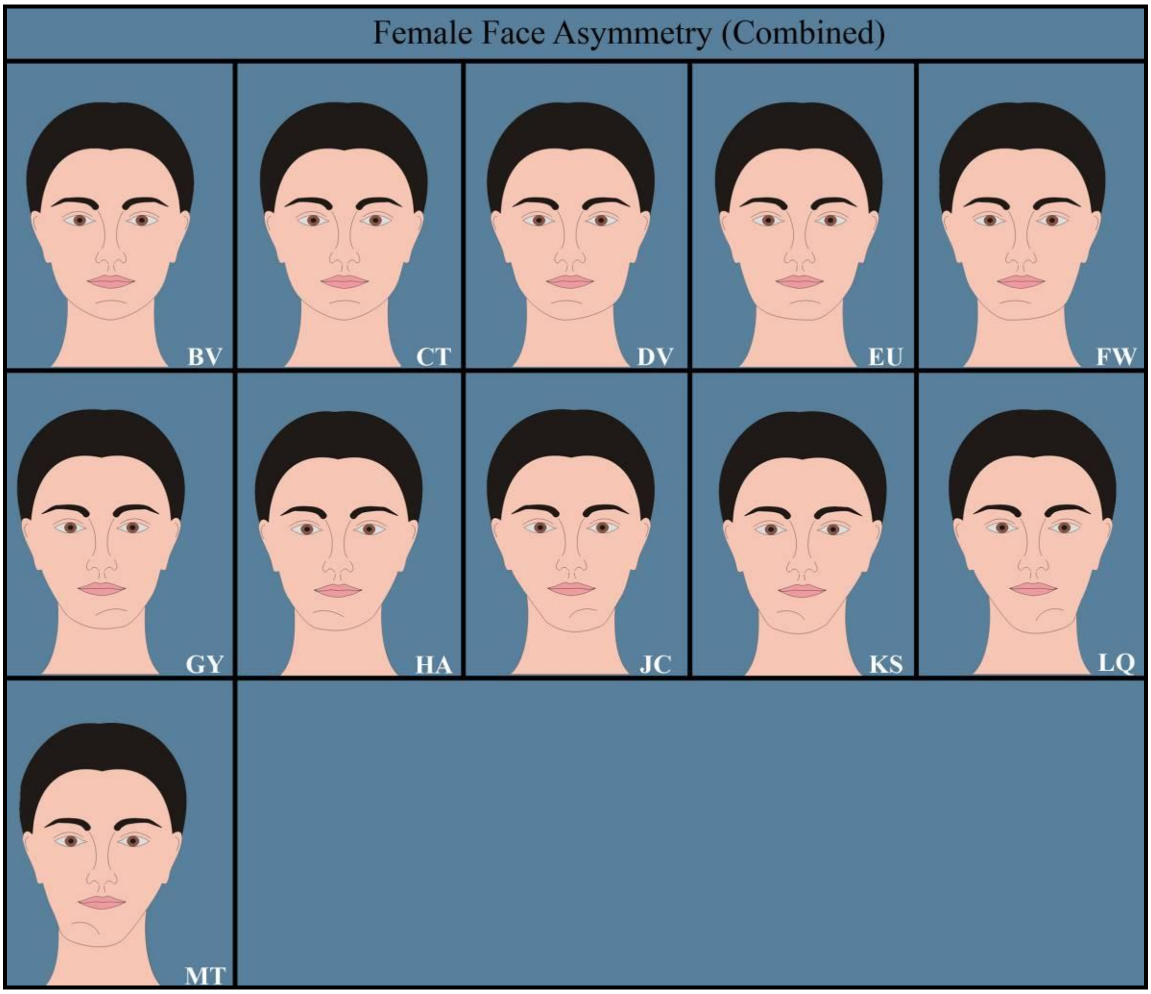

Figure 5.6 Combined mandibular and chin point asymmetry (male face)

5.2.2 *The observers, questionnaire and rating method*

5.2.2.1 Observers

Based on the results of the pilot study described in section 2.2.4, a total of 185 observers took part in the study, separated into 3 groups (pre-treatment orthognathic patients, laypeople and clinicians) (see Table 2.1).

Selection of the three groups of observers followed the selection criteria described in section 2.2.4.1.

5.2.2.2 Questionnaire

Each observer was given a questionnaire thanking them for agreeing to take part in the research. The observers were asked to provide the following information: age, gender, ethnic origin (White or non-White Caucasian), how would you rate the attractiveness of your facial appearance, and how important do you think it is to have an attractive facial appearance.

The observers rated each facial image using the following scale:

1. Extremely unattractive
2. Very unattractive
3. Slightly unattractive
4. Neither attractive nor unattractive
5. Slightly attractive
6. Very attractive
7. Extremely attractive

In addition, observers were asked whether they would consider surgery to correct the appearance if this was their facial appearance.

The images were placed in random order into the software application Microsoft PowerPoint®. Each image was identified by a randomly assigned double letter in the top right corner of the screen (e.g. DR, BP, JZ etc). A duplicate of one of the male images (images DQ and EP) and one of the female images (images DT and ES) was used in order to assess intra-examiner reliability. Each observer sat undisturbed in the same room in front of the same computer and 17” flat screen monitor. The presentation and the images were created in such a way that each of the frontal face images, when viewed on the 17” flat screen monitor, had the same dimensions as a normal human head, based around an average lower anterior facial height. This would help to reduce the potential effect of image magnification or size reduction on the observer’s perception. Each observer examined the images in the PowerPoint® presentation by pressing the 'Page Down' button on the keyboard, in their own time.

5.2.2.3 Rating method

The Likert-type rating scale is largely accepted in the psychology literature as the most useful rating method (Langlois et al., 2000). The seven-point Likert scale described above was used by each observer to rate each image in terms of attractiveness. An example of a section of the questionnaire has been provided (see Figure 2.6).

5.2.3 Statistical analysis

The observer's ratings were recorded in a Likert scale from 1 to 7. Mixed regression was used to assess the differences in ratings for the three groups (pre-treatment orthognathic patients, laypeople, and clinicians) while adjusting for the concurrent effects of age, gender, ethnicity, self-rating for facial attractiveness, the importance given to an attractive facial appearance, the observer's anteroposterior jaw relationship (Class I, II or III), the observer's vertical face height (average, increased or decreased), observer's facial asymmetry (yes/no) and the type of mandibular/chin asymmetry of the images (degree [number of mm of asymmetry], type [horizontal, vertical or combined] and side [left or right]).. The multivariate regression models were fitted in a stepwise manner, including all those variables that reached a significance below P=0.25 univariately. Given the recognised low power of the relevant test, the benchmark for a significant interaction was set at the 10% level. The mixed regression used a multi-level approach to take into account the clustering effect by observer. The model was validated using a logarithmic transformation for the rating scale to assess the effect of departure from normality.

5.3 Results

The variable 'self-rating of attractiveness' had very few observers in both its border values (very unattractive: 7 patients; very attractive: 7 laypeople) and therefore was recoded into two levels: attractive (n=123) vs. unattractive (n=62).

The variable 'vertical face height' was dichotomised into two levels: normal (n=166) vs. non-increased/decreased (n=19).

Only 11 observers responded that attractiveness was very unimportant (1 patient) or unimportant (6 patients and 4 laypeople). As a consequence this variable was dichotomised as very important vs. no very important.

There were only 17 left-handed observers in our sample.

5.3.1 Reliability analysis

A duplicate of one of the images in each section was used in order to assess intra-examiner reliability. On long one-way analysis of variance, the variability between observers, for each pair of replicated images, was highly significant ($P<0.001$): the value of the $F(184,185)$ statistic was 2.9 for the male images and 5.5 for the female images, indicating that there was little variation in the intra-observer ratings for these images. The intra-class correlations were, ICC=0.49 (95% c.i. 0.38 to 0.60), for images DQ and EP, and ICC=0.69 (0.62 to 0.77) for images DT and ES. In both cases the results represent a moderate to good reliability.

5.3.2 Perceived attractiveness of images

Table 5.1 shows the results of the univariate mixed linear regressions for the outcome rating. From the univariate analysis, only the observer's age, observer's jaw relationship (skeletal Class), side and direction of asymmetry of the image and the degree of asymmetry of the image (in mm) were found to have a significant effect on rating.

Group differences were also observed: while no difference was detected between clinicians and patients (P=0.81), significant differences appear between laypeople and clinicians (P=0.01) and patients (P<0.001). Gender of image was not considered in this chapter as it produced very sparse cells.

Table 5.1 Univariate mixed linear regression for rating (male and female images overall)

Rating	Coef.	95% Confidence Interval		P>z
Age	0.01	0.01	0.02	0.001
Gender (Male vs. Female)	0.15	-0.04	0.33	0.12
Ethnicity (White vs. Non-White)	0.12	-0.06	0.31	0.19
Handedness (Left vs. Right)	0.04	-0.27	0.36	0.79
Self-rating of appearance: Attractive vs. Unattractive	-0.03	-0.23	0.16	0.73
Importance of an attractive appearance	-0.07	-0.27	0.13	0.49
Observer's Anteroposterior jaw relationship				0.03
II vs. I	-0.26	-0.49	-0.03	0.03
III vs. I	-0.24	-0.48	-0.01	0.04
II vs. III	-0.02	-0.30	0.27	0.91
II and III vs. I	-0.25	-0.43	-0.07	0.01
Observer's Vertical Lower Anterior Face Height Increased/Decreased vs. Normal	-0.14	-0.44	0.16	0.36
Degree of asymmetry of image (mm)	-0.11	-0.12	-0.11	0.001
Level of Degree of asymmetry of image				0.001
10 vs. 5	-1.09	-1.14	-1.05	0.001
15 vs. 5	-1.65	-1.70	-1.61	0.001
20 vs. 5	-2.01	-2.05	-1.96	0.001
25 vs. 5	-2.36	-2.40	-2.32	0.001
Side of asymmetry of image (right vs. left)	-0.09	-0.14	-0.05	0.001
Type of asymmetry of image				0.002
Horizontal vs. Vertical	0.05	0.00	0.10	0.06
Combined vs. Vertical	0.11	0.06	0.16	0.001
Horizontal vs. Combined	-0.06	-0.11	-0.01	0.02
5.3.3 Observer Group				0.001
Laypeople vs. Patients	0.35	0.15	0.54	0.001
Clinicians vs. Patients	0.03	-0.21	0.27	0.81
Laypeople vs. Clinicians	0.32	0.08	0.56	0.01

On multivariate analysis, the skeletal Class of the observer had a significant effect on rating, with observers with skeletal Class I giving on average 0.24 greater rating than those with skeletal Classes II and III (coeff=0.24; 95% c.i. 0.02 to 0.46; P=0.04). No significant difference was found in the ratings between skeletal Classes II vs. III (coeff=-0.06; 95% c.i. -0.34 to 0.22; P=0.68). Taking into account the distribution of skeletal Class and group, a multivariate linear model excluding skeletal class of the observer is presented in Table 5.2. The following variables retained or gained significance:

Table 5.2 Multivariate mixed linear regressions for rating (n=185) (male and female images overall)

Rating	Coef.	95% Confidence Interval		P>z
Age	0.01	0.00	0.02	0.002
Degree of asymmetry of image (mm)	-0.11	-0.11	-0.11	0.001
10 vs. 5	-0.97	-1.02	-0.93	0.001
15 vs. 5	-1.53	-1.58	-1.49	0.001
20 vs. 5	-1.89	-1.93	-1.84	0.001
25 vs. 5	-2.24	-2.28	-2.20	0.001
Handedness of observer (Left vs. Right)	-0.01	-0.32	0.30	0.04
Side of asymmetry of image (Right vs. Left)	-0.12	-0.24	-0.01	0.03
Interaction of side of asymmetry of image by handedness of observer	0.11	0.00	0.21	0.04
Type of asymmetry of image				0.001
Horizontal vs. Vertical	-0.05	-0.09	-0.02	0.01
Combined vs. Vertical	0.11	0.07	0.14	0.001
Horizontal vs. Combined	-0.16	-0.20	-0.12	0.001
Observer Group				0.01
Laypeople vs. patients	0.24	0.03	0.45	0.03
Clinicians vs. patients	-0.08	-0.34	0.17	0.52
Laypeople vs. Clinicians	0.32	0.08	0.57	0.01

Age of observer – For every ten years older, an observer increased the rating by an average of 10% of a level in the Likert scale (95% c.i. 0.00 to 0.20; P= 0.002).

Degree of asymmetry (of the images) - for each 5 mm increase in the asymmetry of the image, the observer decreased the rating, on average, by 0.6 in the Likert scale (coeff=-0.109; 95% c.i. 0.111 to -0.107; P<0.001).

Alteration side of the image (left-right) and handedness of the observer – The side of asymmetry of the image was shown to have a significant effect on rating, with an indication of an interaction between handedness of the observer and side of asymmetry of the image (P=0.04). In relation to images with asymmetry towards the left, the rating decreased by 0.12 in the Likert scale (coeff=-0.12; 95% c.i. -0.24 to -0.01; P=0.03) in relation to images with the asymmetry towards the right for right-handed observers.

Type of asymmetry of image (comparison of horizontal-only, vertical-only or combined) - In relation to vertical, horizontal asymmetry decreased the rating by 0.05 (coeff=-0.05; 95% c.i. -0.09 to -0.02; P=0.01) and combined asymmetry increased it by 0.11 (coeff=0.11; 95% c.i. 0.07 to 0.14; P<0.001). These results suggest that combined asymmetry received a rating of 16% of a level (in the Likert scale) greater than horizontal and 11% of a level greater than vertical asymmetry.

Observer groups - After adjusting for these effects, a difference of 0.32 was detected between laypeople and clinicians (95% c.i. 0.08 to 0.57; P=0.01) and a difference of 0.24 between laypeople and patients (95% c.i. 0.03 to 0.45; P=0.03). No significant difference was detected between clinicians and patients (coeff=-0.08; 95% c.i. -0.34 to 0.17; P=0.52). Laypeople give a rating of 32% of a level in the Likert scale above clinicians and 24% above patients (ie clinicians and patients are more critical than laypeople).

Neither the gender (P=0.18), handedness (P=0.54) or ethnicity (P=0.16) of the observers was shown to have a significant effect on rating. The variables asymmetry of the observer (P=0.59), self-rating of their own attractiveness (P=0.25), vertical face height (P=0.73) and importance given to attractiveness (P=0.57) did not have any significant effect on the ratings given to the images.

5.3.4 Desire for surgery

The univariate mixed logistic regression for the binary outcome, desire for surgery, is demonstrated in Table 5.3. On univariate analysis the only variables that were shown to be significantly associated with the observer's desire for surgery were the observer's gender, side of asymmetry of the images and the degree of asymmetry of the images (in mm). There was no significant difference in the likelihood of desiring surgery between observer skeletal Classes: II vs. I (P=0.98), III vs. I (P=0.46) and II vs. III (P=0.56). No other group differences were observed: clinicians vs. patients (P=0.77), laypeople vs. patients (P=0.26) and laypeople vs. clinicians (P=0.23).

Table 5.3 Univariate mixed logistic regressions for binary outcome (desire for surgery)

Desire for Surgery	**Odds Ratio (OR)**	**95% Confidence Interval**		**P>z**
Age	0.99	0.98	1.00	0.09
Gender (Male vs. Female)	0.66	0.48	0.91	0.01
Ethnicity (White vs. non-White)	*1.14*	*0.83*	*1.57*	0.42
Handedness (Left vs. Right)	1.01	0.59	1.73	0.97
Importance of an attractive appearance (important vs. not important)	1.09	0.77	1.55	0.62
Asymmetry of observer	1.04	0.56	1.91	0.90
Observer vertical face height (Increased/Decreased vs. Normal)	0.67	0.40	1.11	0.12
Self-rating of appearance (Attractive vs. Unattractive)	1.02	0.74	1.43	0.89
Degree of asymmetry of image				0.001
10 vs. 5	10	8.9	12.1	0.001
15 vs. 5	40	33.0	48.5	0.001
20 vs. 5	89	70.2	112	0.001
25 vs. 5	167	127	219	0.001
Degree of asymmetry of image (mm)	1.35	1.33	1.36	0.001
Side of asymmetry of image (Right vs. Left)	1.17	1.07	1.28	0.001
Type of asymmetry of image				0.20
Horizontal vs. Vertical	1.06	0.95	1.19	0.28
Combined vs. Vertical	1.11	0.99	1.25	0.08
Horizontal vs. Combined	0.96	0.85	1.07	0.47
Observer's Anteroposterior jaw relationship				0.75
II vs. I	1.00	0.67	1.49	0.98
III vs. I	0.86	0.57	1.29	0.46
II vs. III	1.16	0.70	1.92	0.56
Observer's Anteroposterior jaw relationship Classes (II and III) vs. Class I	0.93	0.67	1.27	0.64
Observer Group				0.38
Laypeople vs. Patients	1.22	0.86	1.72	0.26
Clinicians vs. Patients	0.94	0.61	1.44	0.77
Laypeople vs. Clinicians	1.30	0.85	1.99	0.23

On multivariate analysis (Table 5.4), in the presence of observer group, skeletal Class was not significant and therefore was excluded from the model. The following variables retained or gained significance in the multivariate model:

Table 5.4 Multivariate mixed logistic regression for binary outcome (desire for surgery)

Desire for Surgery	**Odds Ratio (OR)**	**95% Confidence Interval**		**P>z**
Age	0.97	0.95	0.99	0.01
Gender (Male vs. Female)	0.47	0.29	0.78	0.001
Ethnicity (White vs. non-White)	1.45	0.88	2.38	0.15
Observer's vertical lower anterior face height Increased/Decreased vs. Average	0.46	0.19	1.09	0.08
Degree of Asymmetry of image				0.001
10 vs. 5	10.5	9.01	12.3	0.001
15 vs. 5	40.5	33.40	49.2	0.001
20 vs. 5	89.8	71.18	113.3	0.001
25 vs. 5	169	128	223	0.001
Side of asymmetry of image	1.30	1.16	1.45	0.001
Observer Group				0.12
Laypeople vs. Patients	1.82	0.98	3.37	0.06
Clinicians vs. Patients	1.10	0.54	2.26	0.79
Laypeople vs. Clinicians	1.7	0.44	6.8	0.45

Age of observer – The odds of wanting surgery reduced by 3% for each year increase in age of the observer (OR = 0.97, 95% c.i. 0.95 to 0.99, P=0.01).

Gender of observer – The odds of wanting surgery were 53% less for men in relation to women (OR = 0.47, 95% c.i. 0.29 to 0.78, P=0.001).

Alteration side (left or right) - If the alteration was on the right side of the image, the observer was 30% more likely to desire surgery than when on the left side (OR = 1.30, 95% c.i. 1.16 to 1.45, P<0.001). No significant interaction between handedness and the side of asymmetry of the image was detected (P=0.60) in terms of desire for surgery.

Relevance of the degree of asymmetry of an image on the observer's desire for surgery (i.e. does the desire for surgery increase with greater degrees of asymmetry)? This was highly relevant. Desire for surgery was negligible for 5 mm of asymmetry. In relation to a 5 mm asymmetry, the odds of wanting surgery increased more than 10-fold for 10 mm of asymmetry, 40-fold for 15 mm, 90-fold for 20 mm and 169-fold for 25 mm of asymmetry.

The following variables were not significant:

Observer's ethnicity - The odds of wanting surgery were 45% greater for White with respect to non-White observers but this difference was not statistically significant.

Observer's vertical lower anterior face height (increased/decreased or average) - The odds of wanting surgery were more than halved for those with increased/decreased facial height in relation to those with average facial height (OR=0.46; 95% c.i. 0.19 to 1.09; P=0.08) but this difference did not reach statistical significance.

Relevance of the type of asymmetry of an image (horizontal, vertical or combined asymmetry) on the observer's desire for surgery - This variable was not shown to have any significant association with the likelihood of wanting surgery (P=0.28). There was essentially no difference in the odds of wanting surgery between horizontal asymmetries in relation to combined (P=0.47) or vertical (P=0.28). Although the odds of wanting surgery for combined asymmetries tended to be greater than for vertical (OR=1.11; 95% c.i. 0.99 to 1.25; P=0.08), this difference did not reach statistical significance.

Patient group jaw relationship - Comparison of skeletal Class II vs. III found no significant difference (OR=0.86; 95% c.i. 0.51 to 1.4; P=0.57) in terms of desire for surgery.

Likewise, the variables asymmetry of the observer (P=0.90), self-rating of their own attractiveness (P=0.89), observer's handedness (P=0.97), importance given to attractiveness (P=0.62) and observer's anteroposterior jaw relationship (skeletal Class I, II or III) (P=0.75) did not have any significant effect on the desire expressed for surgery.

5.3.5 Most attractive and least attractive images

Table 5.5 shows that the lowest rated images were LM and MN, which represented significant degrees of mandibular/chin point asymmetry. The highest rated images were BT and BP, which represented perfect bilateral symmetry. The overall trend demonstrates that milder degrees of asymmetry, e.g. 5 mm, were rated higher, and greater degrees of asymmetry were rated progressively lower and thereby less attractive.

Table 5.5 Mean observer ratings and confidence intervals, ordered from worse to best rating (V = vertical; H = horizontal; R = right; L = left; m = male; f = female)

Image	Asymmetry (mm)	Mean	SD	95% confidence interval		Median
LM	25 VR m	1.29	0.71	1.18	1.39	1
MN	25 VL m	1.29	0.66	1.19	1.38	1
MM	25 HL m	1.32	0.67	1.23	1.42	1
LN	25 CL m	1.33	0.66	1.23	1.43	1
MO	25 CR m	1.37	0.76	1.26	1.48	1
KO	20 VL m	1.42	0.80	1.31	1.54	1
LP	25 VR f	1.42	0.80	1.31	1.54	1
JY	20 VR m	1.43	0.78	1.31	1.54	1
OW	25 HR m	1.49	0.85	1.36	1.61	1
KR	20 VL f	1.56	0.87	1.44	1.69	1
JB	20 VR f	1.61	0.90	1.48	1.74	1
MR	25 VL f	1.61	0.89	1.48	1.74	1
OY	25 HR f	1.63	0.76	1.52	1.74	1
LL	20 HR m	1.66	0.81	1.54	1.78	1
JX	15 HR m	1.71	0.86	1.59	1.84	2
MQ	25 HL f	1.72	0.86	1.59	1.84	2
HV	15 HL m	1.72	0.84	1.60	1.84	2
MT	25 CL f	1.78	0.89	1.66	1.91	2
LQ	25 CR f	1.80	0.85	1.68	1.92	2
KN	20 HL m	1.86	1.01	1.72	2.01	2
GU	15 VR m	1.91	0.97	1.77	2.05	2
KP	20 CR m	1.93	0.95	1.79	2.07	2
HW	15 VL m	1.97	0.94	1.84	2.11	2

Image	Asymmetry (mm)	Mean	SD	95% confidence interval		Median
KQ	20 HL f	1.99	0.94	1.86	2.13	2
LO	20 HR f	2.02	1.01	1.88	2.17	2
JC	20 CR f	2.03	0.93	1.90	2.17	2
FP	10 HL m	2.06	0.97	1.92	2.20	2
GV	15 CL m	2.09	0.99	1.95	2.23	2
HY	15 HL f	2.09	0.90	1.96	2.22	2
HZ	15 VL f	2.10	0.98	1.96	2.24	2
ER	10 CL m	2.15	1.04	2.00	2.30	2
GX	15 VR f	2.15	0.89	2.02	2.27	2
JA	15 HR f	2.22	0.92	2.09	2.35	2
FR	10 CR m	2.27	1.00	2.13	2.41	2
GT	10 HR m	2.28	0.99	2.14	2.42	2
KS	20 CL f	2.33	1.03	2.18	2.48	2
JZ	20 CL m	2.42	1.04	2.27	2.57	2
HX	15 CR m	2.49	0.97	2.35	2.63	3
FS	10 HL f	2.62	0.86	2.49	2.74	2
FQ	10 VL m	2.76	0.96	2.62	2.89	3
GW	10 HR f	2.89	1.00	2.75	3.04	3
HA	15 CL f	2.97	1.06	2.82	3.13	3
ET	10 VR f	3.09	0.99	2.94	3.23	3
GY	15 CR f	3.09	1.09	2.94	3.25	3
EQ	10 VR m	3.10	1.02	2.96	3.25	3
DQ	5 HR m	3.17	1.09	3.02	3.33	3
FW	10 CL f	3.17	1.07	3.02	3.33	3
DS	5 CR m	3.19	1.07	3.03	3.34	3
FT	10 VL f	3.26	1.02	3.12	3.41	3
CT	5 CR f	3.36	1.14	3.19	3.52	3
CQ	5 CL m	3.42	1.19	3.25	3.59	3
DV	5 CL f	3.46	1.07	3.31	3.61	4
EU	10 CR f	3.59	0.92	3.46	3.73	4
CP	5 VR m	3.68	1.05	3.52	3.83	4
EP	5 HR m	3.71	1.13	3.55	3.88	4
CO	5 HL m	3.81	1.09	3.65	3.96	4
CS	5 VR f	3.89	1.05	3.74	4.04	4
CR	5 HL f	3.97	0.90	3.84	4.10	4
ES	5 HR f	3.98	0.96	3.84	4.12	4
DT	5 HR f	4.01	0.97	3.87	4.15	4
DU	5 VL f	4.18	0.97	4.04	4.32	4
DR	5 VL m	4.40	0.84	4.28	4.52	5
BP	0 m	4.78	0.51	4.70	4.85	5
BT	0 f	4.82	0.46	4.76	4.89	5

5.4 Discussion

It has been documented that perfect bilateral facial symmetry is not normal (Burke, 1971; Peck and Peck, 1991). Nevertheless, though a small degree of asymmetry may be deemed within normal limits, beyond this asymmetries are likely to be noticeable and thereby a potentially important parameter in perceptions of facial attractiveness.

A large number of studies have been undertaken to assess the psychological factors involved in perceptions of facial attractiveness (Langlois et al., 2000). However, the purpose of the present investigation was to provide clinically relevant data by evaluating the perceptions of attractiveness for mandibular and chin point asymmetry, in order to provide objective evidence to guide clinicians involved in the treatment planning of patients with asymmetric jaw deformities.

In order to determine and validate the correct facial proportions with which to plan clinical treatment, two sources of information are required (Naini et al., 2008). Firstly, population averages, which permit comparison of an individuals facial measurements and proportions to the population norms. Such data must be age, gender and ethnicity specific. Such data is available from anthropometric studies (Farkas and Cheung, 1981) and long term cephalometric growth studies of normal individuals (Broadbent et al., 1975; Cortella et al., 1997). Secondly, the perceived attractiveness of the proportions must be confirmed by the judgement of patients and the lay public, and ideally compared to the judgement of treating clinicians. This was the main purpose of this investigation.

5.4.1 Hypothesis testing

The first part of the null hypothesis was that 'there is no effect of the type or degree/severity of asymmetry of the mandible and chin point on perceived attractiveness and desire for surgery.' We reject this null hypothesis, as the results of this study found an effect of the type and degree/severity of asymmetry of the mandible and chin point on perceived attractiveness and desire for surgery. The second part of the null hypothesis was that 'Likewise, there is no difference in the perception of orthognathic patients, laypeople and clinicians.' We reject this null hypothesis, as the results of this study found a difference in the perceptions of the observer groups.

5.4.2 Influence of the degree of asymmetry of the image

The results of this study demonstrate that the degree of asymmetry seems to become significantly more noticeable from an asymmetry of 10 mm and the observer's attractiveness ratings decrease alongside increases in the degree of asymmetry. The percentage of images rated unattractive more than doubles for a degree of asymmetry of 10mm and above, in relation to a degree of asymmetry of 5mm or below.

In relation to an asymmetry of 5 mm, the observer ratings decreased by one level of the Likert scale for an asymmetry of 10 mm, by 1.6 of a level of the Likert scale for an asymmetry of 15 mm and by 2 levels of the Likert scale for an asymmetry of 20-25 mm. The odds of being rated as unattractive were 10 times greater for 10 mm of asymmetry in relation to 5 mm asymmetry, and the odds increased alongside increases in the degree of asymmetry.

5.4.3 At what degree of asymmetry does the asymmetry become so noticeable that patients want (or clinicians or laypeople recommend) surgical correction?

Mandibular and chin point asymmetry appears to be readily observed at 10mm. In relation to 5mm, the odds of desire for surgery were found to be 8 times greater at 10mm and increased across higher levels of asymmetry. The clinical implication is that mandibular and chin point asymmetries of less than 5mm may potentially be accepted, albeit with involvement of the patient in treatment planning and with their informed consent.

5.4.4 Influence of the type of asymmetry of the image, i.e. which type of asymmetry appears to be the most noticeable (horizontal, vertical or combined)?

Combined asymmetry was perceived as only slightly worse than vertical. The worse perceived asymmetry was the horizontal, although the effect was not significant. The odds of wanting surgery increased by 11% for combined asymmetry in relation to vertical (P=0.06). There was essentially no difference in the odds of wanting surgery between horizontal asymmetries in relation to combined (P=0.47) or vertical (P=0.28). Therefore, it appears that horizontal asymmetries of the mandible and chin point, such as those seen in hemimandibular elongation, are perceived as worse than vertical asymmetries, such as hemimandibular hyperplasia, though the effect is not significant. However, thought the degree of asymmetry is important, the type of asymmetry does not appear to be a factor in the desire for surgery.

5.4.5 Influence of observer group and professional status

The results indicate that pre-treatment orthognathic patients are more critical than laypeople and clinicians are also more critical than laypeople. However, no significant differences were found between clinicians and patients. Clinicians will develop enhanced critical faculties as a result of their training and it may be that the very existence of a facial asymmetry will lead to patients developing a greater sensitivity to noticeable differences in facial appearance from the ‘ideal’. Previous studies have found significant differences between the perceptions of facial profile attractiveness of orthodontists and maxillofacial surgeons compared with laypeople (Cochrane et al., 1999). Attractiveness studies often use laypeople as observer’s but seldom use patients.

The results of the present investigation, finding that orthognathic patients were more critical than laypeople, suggests that in future studies greater emphasis may be put on evaluating the perceptions of patients as opposed to laypeople.

The observer's gender, ethnicity, left or right-handedness, asymmetry of the observer, vertical face height, self-rating of their own appearance and importance given to an attractive facial appearance had no significant effect on attractiveness ratings. Previous studies have alluded to the possibility of an individual's handedness and perception of asymmetry (Zaidel et al., 1995; Chen et al., 1997). The interaction between the observer's 'handedness' and 'side of asymmetry of image (right vs. left)' in this study was shown to be significant; in relation to images with asymmetry towards the left, the rating decreased by 0.12 in the Likert scale in relation to images with the asymmetry towards the right for right-handed observers. Previous studies, albeit assessing the attractiveness of facial profiles, found no evidence to suggest that the gender of an observer significantly influences attractiveness ratings (De Smit and Dermaut, 1984; Cochrane et al., 1997).

5.4.6 Desire for surgery

The odds of wanting surgery reduced with increases in age of the observers. The reasons for this may be manifold, including a potentially greater preoccupation with the facial appearance at a younger age and possibly more stability in lifestyle in older individuals. The odds of wanting surgery were found to be less for men than women and greater for White with respect to non-White observers.

The desire for surgery was negligible for 5 mm of asymmetry but increased considerably (10-fold) at 10 mm of asymmetry, 40-fold for 15 mm, 90-fold for 20 mm and 169-fold for 25 mm of asymmetry. The implication is that, in terms of asymmetry of the mandible/chin alone, surgical treatment is not desired with asymmetries less than 5 mm and is considered desirable for asymmetries greater than 10 mm.

The variables asymmetry of the observer, self-rating of their own attractiveness, observer's handedness, importance given to attractiveness and observer's anteroposterior jaw relationship did not have any significant effect on the desire expressed for surgery, though a borderline significant effect was found as the odds of wanting surgery were halved for those with increased/decreased facial height in relation to those with average facial height.

5.4.7 Most attractive and least attractive images

The highest rated images (BT and BP) demonstrate perfect bilateral symmetry and the lowest rated images (LM and MN) demonstrate significant degrees of mandibular and chin point asymmetry. The overall trend demonstrates that milder degrees of asymmetry, e.g. 5 mm, were rated as more attractive and greater degrees of asymmetry were rated as progressively less attractive. Although the relationship between bilateral facial symmetry and beauty remains to be clarified (Rhodes et al., 1999), the results of this investigation support previous evidence that mild facial asymmetry is compatible with an attractive facial appearance (Zaidel and Cohen, 2005).

5.5 Conclusions

From the results of this study it appears that mandibular/chin point asymmetry of 10 mm is perceived as significant; at 5 mm (and thereby below 5 mm) it appears to be largely irrelevant to the observer in terms of desire for surgery. The greater the degree of asymmetry past 10 mm, the more noticeable it becomes. From 10 mm of asymmetry upwards, patients desire treatment for correction of the asymmetry.

It was also observed that horizontal asymmetry, akin to hemimandibular elongation, appears to be perceived as the most unattractive type of asymmetry, though at greater degrees of asymmetry all types of asymmetry are rated as unattractive.

Observer group differences demonstrated a difference of 0.32 between laypeople and clinicians (p-value = 0.01) and a difference of 0.24 between laypeople and patients (p-value = 0.03) but no significant difference between clinicians and patients (p-value = 0.52) for attractiveness ratings. Laypeople gave a rating of 0.32 higher than clinicians (95% c.i. 0.08 to 0.57, p-value = 0.01) (Table 5.2), i.e. clinicians and patients are more critical than laypeople. This stresses the importance of using patients and clinicians as observers in attractiveness studies, rather than just laypeople.

The observer's gender, handedness, and ethnicity, did not have a significant effect on rating. In terms of age, on average, for every year older, the observer is 3% less likely to desire surgery (OR = 0.96, 95% c.i. 0.94 to 0.99, p-value = 0.01). In terms of gender, men are 53% less likely to want surgery than women (OR = 0.47, 95% c.i. 0.25 to 0.87, p-value = 0.02). In terms of the alteration side, if on the right side, the desire for surgery is 30% greater than if the alteration is on the left side (OR = 1.30, 95% c.i. 1.16 to 1.45, p-value <0.001).

Desire for surgery was negligible for 5 mm of asymmetry but increased considerably at 10 mm of asymmetry and continued to increase with greater degrees of asymmetry.

The highest rated images (BT and BP) demonstrate perfect bilateral symmetry and the lowest rated images (LM and MN) demonstrate significant degrees of mandibular/chin asymmetry. Therefore, the clinician's pursuit of attaining a result as close to bilateral symmetry as attainable is a worthy treatment aim.

6 The influence of facial profile convexity on perceived attractiveness

6.1 Introduction

The facial profile is an important determinant of attractiveness and may be described in terms of its overall contour (straight, convex or concave) and its overall inclination (neutral, posteriorly or anteriorly divergent). The overall contour of the facial profile may be described by the relationship between two lines or planes: the upper facial plane, connecting soft tissue glabella to subnasale, and the lower facial plane, connecting subnasale to soft tissue pogonion. In a straight profile, these two lines form a nearly straight line. An angle between these two lines indicates facial profile convexity or concavity. Where no angle exists between the two lines, their overall inclination determines the divergence of the facial profile (Naini, 2011).

Furthermore, the *lower* face may also be described in terms of its contour and inclination in isolation from the above. The appearance of *lower* facial convexity or concavity may occur as a result of simple chin retrusion or protrusion respectively, with little change in the lip prominence. However, in some individuals *total* lower facial convexity or concavity occurs, due to posterior or anterior divergence of the *entire* lower face (Figure 6.1). Whereas lower facial profile contour is often characterized by retrusion or protrusion of the chin with normal sagittal lip position, some individuals exhibit posterior or anterior divergence of the entire lower face, leading to a convex or concave appearance of the entire lower face, from subnasale downwards. For example, an individual with a convex and posteriorly divergent lower face will often have mandibular retrognathia/retrogenia and an element of maxillary retrognathia. Treatment for such an individual may require bimaxillary advancement as opposed to only mandibular advancement.

A facial deformity often results from a significant deviation of one or more facial parameters from the accepted norm for a population. The magnitude of the deviation is an important factor in decision-making when jaw surgery may be required. If the magnitude of the discrepancy of a facial parameter is great (e.g. significant lower facial profile convexity) then the treatment planning decision may be relatively straightforward. However, there are a significant number of patients who are regarded as 'borderline' in terms of need for surgical treatment. In such patients, the decision making process may be transferred from subjective clinical judgement to objective, evidence-based guidance based on data from studies investigating perceptions of facial attractiveness (Naini et al., 2008).

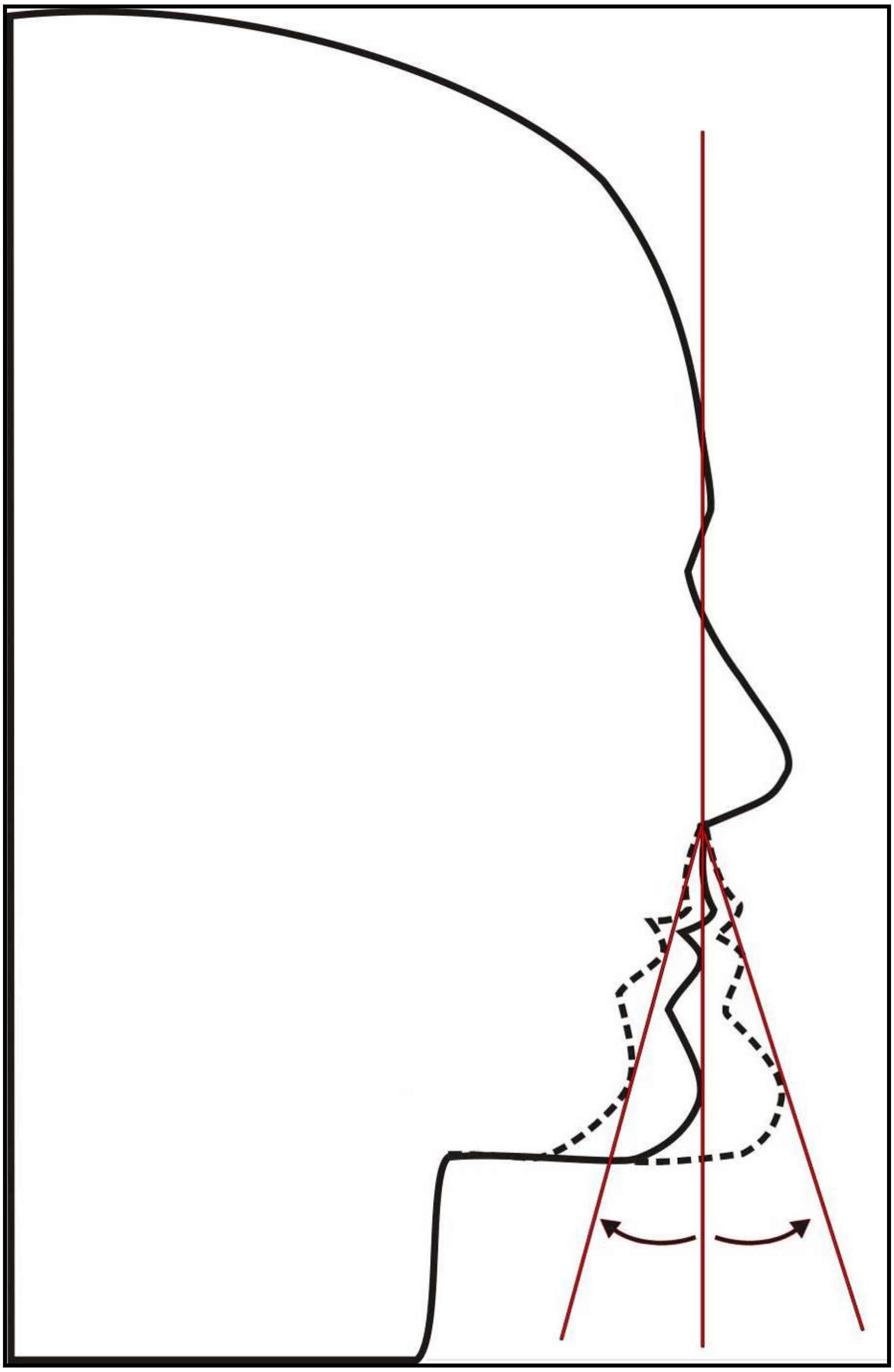

Figure 6.1 Lower facial convexity angle; demonstrating posterior and anterior divergence of the entire lower facial plane

Facial profile convexity is a potentially important factor in the perception of facial attractiveness. The purpose of this study was to find objective evidence to aid clinicians in planning the treatment of patients requiring corrective jaw surgery.

The principal aim of this investigation was to quantitatively evaluate the influence of lower facial profile convexity on perceived attractiveness. In addition, the relationship between degree of convexity and attractiveness was recorded to ascertain the range of normal variability, in terms of observer acceptance, and determine the clinically significant threshold value or cut-off point, beyond which the degree of facial profile convexity is perceived as unattractive and treatment is desired. Finally, the perception of orthognathic patients, clinicians and laypeople were compared for these different variables.

6.2 Subjects and Methods

6.2.1 The Images

Two-dimensional facial profile silhouettes have been routinely used to assess the perceptions of facial profile attractiveness (Barrer and Ghafari, 1985; Ioi et al., 2005).
A facial profile silhouette image was created with computer software (Adobe® Photoshop® CS2 software; Adobe Systems Inc, San Jose, CA). The image was then manipulated using the same computer software to construct an 'ideal' facial profile image with proportions (Naini, 2011) and soft tissue measurements (Farkas et al., 1984; Farkas et al., 1985; Farkas et al., 1986; Farkas and Kolar, 1987; Farkas, 1994; Naini, 2011) based on currently accepted criteria (see Figures 2.4 and 2.5).

6.2.1.1 Profile image manipulation (incremental)

The lower facial plane (subnasale to soft tissue pogonion) of the image was manipulated, in 2 degree increments, from 0 to 14 degrees backwards (section 1) and from 0 to -16 degrees forwards (section 2), rotating around subnasale, in order to represent increased and reduced lower facial profile convexity respectively (Figures 6.2 and 6.3).

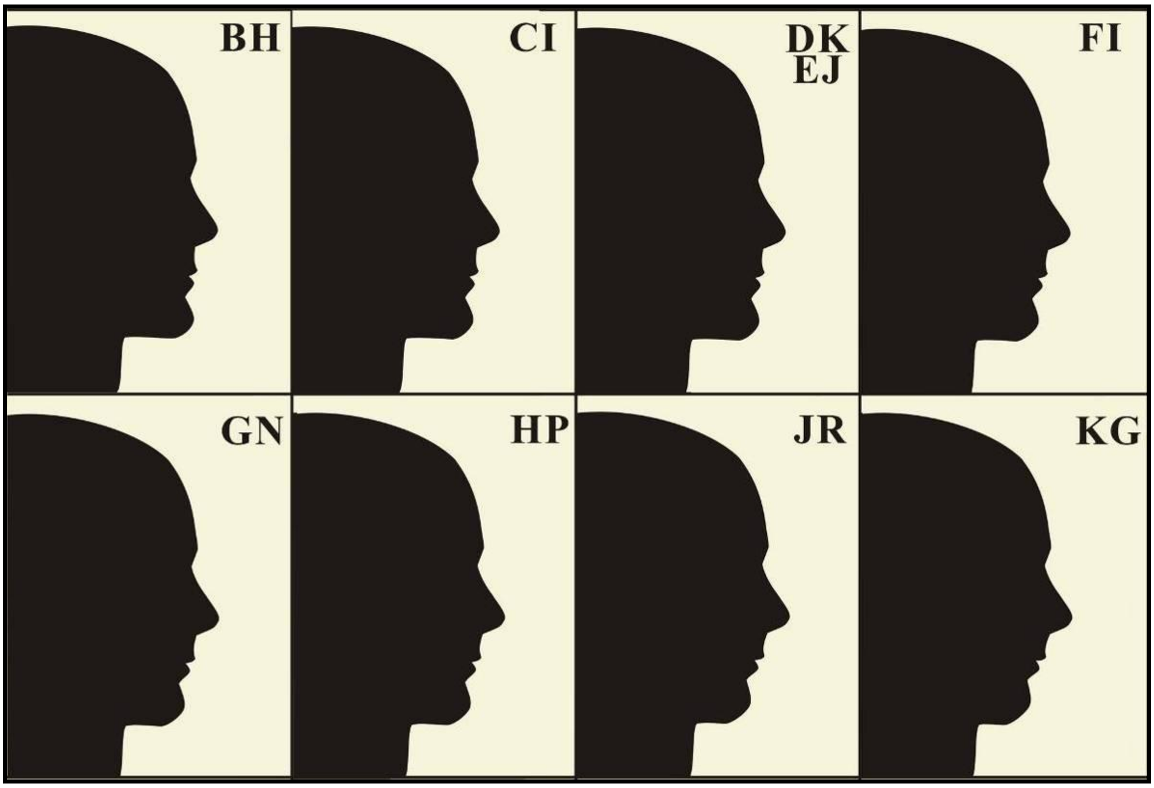

Figure 6.2 Section 1, lower facial plane (backwards), altered in 2° increments, from 0° to 14°

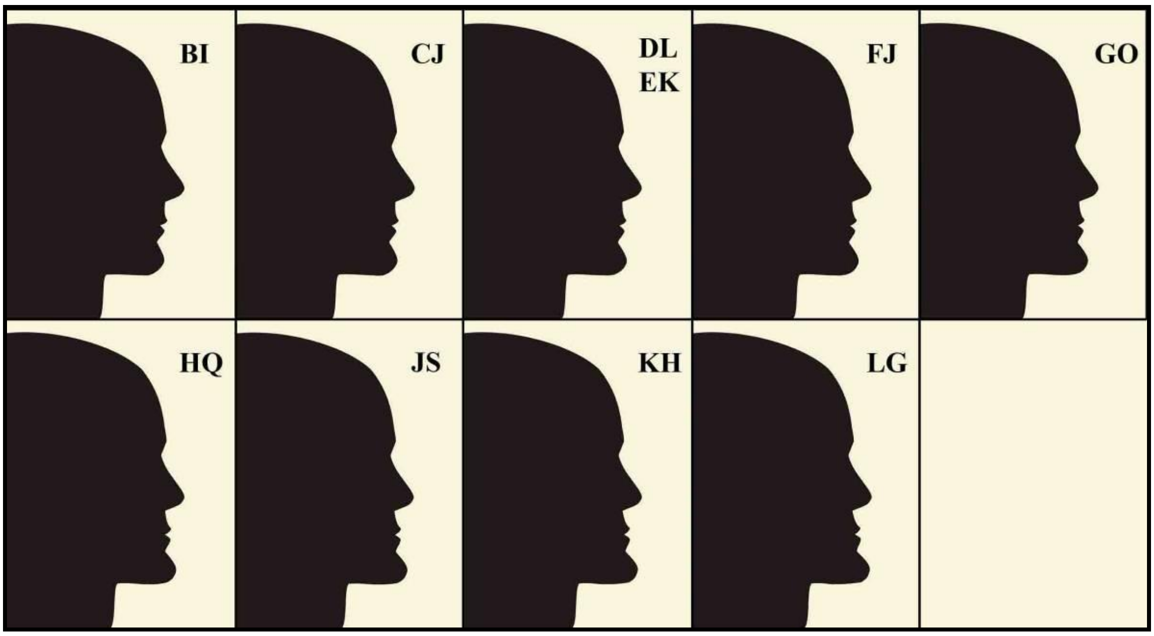

Figure 6.3 Section 2, lower facial plane (forwards), altered in 2° increments, from 0° to -16°

6.2.2 The observers, questionnaire and rating method

6.2.2.1 Observers

Based on the results of the pilot study described in section 2.2.4, a total of 185 observers took part in the study, separated into 3 groups (pre-treatment orthognathic patients, laypeople and clinicians) (see Table 2.1).

Selection of the three groups of observers followed the selection criteria described in section 2.2.4.1.

6.2.2.2 Questionnaire

Each observer was given a questionnaire thanking them for agreeing to take part in the research. The observers were asked to provide the following information: age, gender, ethnic origin (White or non-White Caucasian), how would you rate the attractiveness of your facial appearance, and how important do you think it is to have an attractive facial appearance.

The observers rated each facial image using the following scale:

1. Extremely unattractive
2. Very unattractive
3. Slightly unattractive
4. Neither attractive nor unattractive
5. Slightly attractive
6. Very attractive
7. Extremely attractive

In addition, observers were asked whether they would consider surgery to correct the appearance if this was their facial appearance.

Two groups of images were represented (sections 1 and 2). The images were placed in random order into Microsoft PowerPoint®. Each image was identified by a randomly assigned double letter in the top right corner of the screen (e.g. BH). A duplicate of one of the images in each group was used in order to assess intra-examiner reliability. Each observer sat undisturbed in the same room in front of the same computer and 17” flat screen monitor. The presentation and the images were created in such a way that each of the profile silhouette images, when viewed on the 17” flat screen monitor, had the same dimensions as a normal human head, based around an average lower anterior facial height. This would help to reduce the potential effect of image magnification or size reduction on the observer’s perception. Each observer examined the images in the PowerPoint® presentation by pressing the ‘Page Down’ button on the keyboard, in their own time.

6.2.2.3 Rating method

The Likert-type rating scale is largely accepted in the psychology literature as the most useful rating method (Langlois et al., 2000). The seven-point Likert scale described above was used by each observer to rate each image in terms of attractiveness. An example of a section of the questionnaire has been provided (see Figure 2.6).

6.2.3 Statistical analysis

The observer’s ratings were recorded in a Likert scale from 1 to 7. Mixed regression was used to assess the differences in ratings for the three groups while adjusting for the concurrent effects of age, gender, ethnicity, self-rating for facial attractiveness, the importance given to an attractive facial appearance, the observer’s anteroposterior jaw relationship, face height and asymmetry, and the degree of lower facial profile convexity of the images. The multivariate regression models were fitted in a stepwise manner, including all those variables that reach a significance below P=0.25 when assessed univariately. Given the recognised low power of the relevant test, the benchmark for a significant interaction was set at the 10% level.

6.3 Results

All the laypeople and the clinicians were skeletal Class I while 96% of the patients were Class II or III. There was no significant difference in perceptions of attractiveness between observer's with Class II and III jaw relationships (P=0.91) but they appeared to differ significantly from those with skeletal Class I. When skeletal Class was fitted on the patient group alone no difference was detected between Classes II and III (P=0.86).

6.3.1 Reliability analysis

A duplicate of one of the images in each section was used to assess intra-examiner reliability. On long one-way analysis of variance, the variability between observers was highly significant (P<0.001) indicating little variation in the intra-observer ratings.

6.3.2 Perceived attractiveness of images

Table 6.1 shows the results of the univariate mixed linear regressions for the outcome rating and table 6.2 shows the results of the multivariate mixed linear regressions for the outcome rating. Effects of observer age and gender were detected, which were different for the different sections. Observer age was not found to have a significant effect in section 2 but had a highly significant effect in section 1 with older people giving higher ratings. The mean rating in section 1 increased by 0.01 of a level of the Likert scale for each year older. A significant effect of observer gender was not found in either section.

Table 6.1 Univariate mixed linear regressions for the outcome rating

	Overall		Section 1		Section 2	
Description	**Coef. - Interval**	**P value**	**Coef. - Interval**	**P value**	**Coef. - Interval**	**P value**
Age	0.01 (0.00, 0.02)	0.038	0.01 (0.01, 0.02)	0.002	0.00 (0.00, 0.01)	0.355
Gender (Male vs. Female)	0.21 (0.01, 0.41)	0.04	-0.03 (-0.28, 0.21)	0.79	0.21 (-0.01, 0.42)	0.06
Ethnicity (White vs. non-White)	-0.16 (-0.36, 0.04)	0.11	-0.17 (-0.41, 0.07)	0.16	-0.12 (-0.34, 0.09)	0.25
Handedness (Left vs. Right)	-0.02 (-0.36, 0.32)	0.90	0.05 (-0.36, 0.46)	0.81	-0.04 (-0.41, 0.32)	0.81
Self-rating of appearance	0.12 (-0.09, 0.32)	0.27	0.10 (-0.15, 0.35)	0.45	0.16 (-0.06, 0.38)	0.16
Importance of an attractive appearance	0.49 (0.08, 0.90)	0.02	0.38 (-0.12, 0.88)	0.14	0.32 (-0.12, 0.76)	0.16
Observer's Skeletal Class		0.01		0.007		0.03
II vs. I	-0.32 (-0.56, -0.07)	0.01	-0.45 (-0.75, -0.15)	0.003	-0.21 (-0.47, 0.06)	0.12
III vs. I	-0.29 (-0.54, -0.04)	0.03	-0.27 (-0.58, 0.03)	0.08	-0.34 (-0.61, -0.07)	0.01
II vs. III	-0.03 (-0.33, 0.28)	0.86	-0.18 (-0.55, 0.19)	0.35	0.14 (-0.19, 0.46)	0.42
Observer's Skeletal Class (II and III vs. I)	-0.30 (-0.50, -0.11)	0.002	-0.37 (-0.60, -0.13)	0.003	-0.27 (-0.49, -0.06)	0.01
Observer's vertical lower anterior face height	0.22 (-0.10, 0.54)	0.17	0.18 (-0.21, 0.57)	0.38	0.16 (-0.19, 0.50)	0.37
Angle of convexity	0.01 (0.01, 0.02)	0.001	0.27 (0.26, 0.28)	0.001	-0.22 (-0.23, -0.21)	0.001
Angle of convexity (Positives vs. Negatives)	0.35 (0.27, 0.43)	0.001	1.82 (1.61, 2.02)	0.001	3.83 (3.73, 3.94)	0.001
Section		0.001				
2 vs. 1	-0.35 (-0.45, -0.26)	0.001				
Observer Group		0.01		0.001		0.04
Laypeople vs. Patients	0.33 (0.12, 0.55)	0.002	0.52 (0.27, 0.77)	0.001	0.26 (0.03, 0.49)	0.03
Clinicians vs. Patients	0.25 (-0.01, 0.52)	0.06	-0.02 (-0.34, 0.29)	0.89	0.31 (0.02, 0.59)	0.04
Laypeople vs. Clinicians	0.08 (-0.18, 0.34)	0.55	0.54 (0.23, 0.85)	0.001	-0.05 (-0.33, 0.24)	0.74

Table 6.2 Multivariate mixed linear regressions for the outcome rating

	Overall		Section 1		Section 2	
Description	**Coeffcient (95% CI)**	**P value**	**Coeffcient (95% CI)**	**P value**	**Coeffcient (95% CI)**	**P value**
Age	0.01 (0.00, 0.01)	0.35	0.01 (0.00, 0.02)	0.03		
Importance of an attractive appearance	0.42 (0.02, 0.83)	0.04				
Angle of convexity	0.04 (0.04, 0.05)	0.001	0.27 (0.26, 0.28)	0.001	-0.22 (-0.23, -0.21)	0.001
Section		0.001				
1 vs. 2	-0.10 (-0.20, -0.01)	0.03				
Observer Group		0.05		0.001		0.04
Laypeople vs. Patients	0.28 (0.05, 0.50)	0.02	0.42 (0.15, 0.68)	0.002	0.26 (0.03,0.49)	0.03
Clinicians vs. Patients	0.18 (-0.10, 0.45)	0.2	-0.12 (-0.44, 0.20)	0.48	0.31 (0.02,0.59)	0.04
Laypeople vs. Clinicians	0.10 (-0.16, 0.36)	0.46	0.53 (0.22, 0.84)	0.001	-0.05 (-0.33,0.24)	0.74

The angle of lower facial profile convexity was found to have a highly significant association with ratings of attractiveness. Ratings of attractiveness decrease by 0.22 of a level of the Likert scale for every degree increase in the facial profile convexity angle for section 2 and increased by 0.27 of a level of the Likert scale for section 1. After adjusting for these effects, the mean rating was shown to be significantly different between the groups with:

Clinicians giving a greater mean rating for attractiveness than patients in section 2 but not in section 1,

Laypeople giving a greater mean rating for attractiveness than patients in sections 1 and 2, and

Laypeople giving a greater mean rating for attractiveness than clinicians in section 1 but not in section 2.

In relation to skeletal Class I, orthognathic patients with Classes II and III gave significantly reduced ratings of attractiveness, but there was no difference between Classes II and III patients (Table 6.3).

Table 6.3 Multivariate mixed linear regression for rating (orthognathic patient group)

Description	Coef.	95% Conf. Interval		P-value
Age	0.003	-0.01	0.02	0.69
Gender (Male vs. Female)	0.02	-0.24	0.28	0.88
Importance of an attractive appearance	0.09	-0.37	0.55	0.70
Angle of convexity	0.01	0.00	0.02	0.004
Observer's skeletal Class (Anteroposterior relationship)				0.94
II vs. I	-0.11	-0.79	0.56	0.74
III vs. I	-0.09	-0.78	0.60	0.81
II vs. III	-0.03	-0.30	0.25	0.85

6.3.3 Desire for surgery

The univariate mixed logistic regression for the binary outcome, desire for surgery, is demonstrated in table 6.4. The multivariate logistic regression (Table 6.5), demonstrated that covariate and group effects were different for the different sections.

Observer age had a highly significant effect in section 1, with the odds of desire for surgery decreasing by 6% for each year increase in age.

Observer gender had a highly significant effect in section 2. The odds of desire for surgery were 62% less for men than for women.

The effect of 'importance of an attractive appearance' was only seen in section 1. The odds of desire for surgery were 4.5 times greater for observers who said attractiveness is important in relation to those who said it was unimportant.

An effect of ethnicity was observed in section 2. The odds of desire for surgery were double for the non-white in relation to the white Caucasian observers.

The effect of the lower facial profile convexity angle was very significant in both sections. The odds of desire for surgery increased by 60% for each degree increase in the facial profile convexity angle in section 2 and almost doubled in section 1.

Table 6.4 Univariate mixed logistic regression for binary outcome: desire for surgery

	Overall		Section 1		Section 2	
Variable description	**OR / CI**	**P value**	**OR / CI**	**P value**	**OR / CI**	**P value**
Age	0.98 (0.97, 0.99)	0.001	0.97 (0.96, 0.99)	0.001	0.99 (0.98, 1.00)	0.21
Gender (Male vs. Female)	0.68 (0.51, 0.89)	0.01	0.80 (0.59, 1.09)	0.15	0.62 (0.45, 0.85)	0.003
Ethnicity (White vs. non-White)	1.28 (0.97, 1.68)	0.083	1.14 (0.84, 1.55)	0.39	1.36 (0.98, 1.88)	0.06
Handedness (Left vs. Right)	0.85 (0.53, 1.36)	0.49	0.81 (0.48, 1.36)	0.42	0.90 (0.52, 1.56)	0.70
Self-rating of appearance	0.86 (0.65, 1.15)	0.31	0.96 (0.70, 1.32)	0.82	0.75 (0.54, 1.05)	0.09
Importance of an attractive appearance	1.13 (0.63, 2.01)	0.69	1.56 (0.82, 2.97)	0.18	1.10 (0.56, 2.16)	0.78
Observer's Skeletal Class (Anteroposterior relationship)		0.004		0.004		0.02
II vs. I	1.58 (1.12, 2.21)	0.01	1.80 (1.24, 2.62)	0.002	1.19 (0.80, 1.78)	0.39
III vs. I	1.59 (1.13, 2.24)	0.01	1.45 (0.99, 2.11)	0.05	1.77 (1.19, 2.66)	0.01
II vs. III	1.01 (0.68, 1.50)	0.97	1.24 (0.79, 1.97)	0.35	0.67 (0.41, 1.10)	0.11
Observer's Skeletal Class (II and III vs. I)	1.58 (1.21, 2.07)	0.001	1.62 (1.20, 2.18)	0.001	1.45 (1.05, 2.00)	0.02
Observer's vertical lower anterior face height	0.89 (0.57, 1.38)	0.59	0.86 (0.52, 1.40)	0.53	0.92 (0.54, 1.54)	0.74
Angle of convexity	0.99 (0.98, 1.00)	0.02	0.53 (0.49, 0.57)	0.001	1.57 (1.50, 1.65)	0.001
Angle of convexity (Positives vs. Negatives)	0.76 (0.68, 0.86)	0.001	0.06 (0.03, 0.11)	0.001		
Section		0.001				
2 vs. 1	1.89 (1.62, 2.21)	0.001				
3 vs. 1	1.64 (1.41, 1.90)	0.001				
2 vs. 3	1.16 (1.00, 1.34)	0.05				
Observer Group		0.01		0.01		0.02
Laypeople vs. Patients	0.72 (0.53, 0.96)	0.03	0.61 (0.44, 0.84)	0.003	0.83 (0.59, 1.17)	0.294
Clinicians vs. Patients	0.58 (0.40, 0.83)	0.003	0.84 (0.56, 1.25)	0.38	0.54 (0.35, 0.82)	0.004
Laypeople vs. Clinicians	0.81 (0.56, 1.16)	0.3	0.72 (0.48, 1.08)	0.11	1.56 (1.01, 2.40)	0.05

Table 6.5 Multivariate mixed logistic regression for binary outcome: desire for surgery

	Overall		Section 1		Section 2	
Description	**Odds Ratio (CI)**	**P value**	**Odds Ratio (CI)**	**P value**	**Odds Ratio (CI)**	**P value**
Age	0.98 (0.97, 0.99)	0.001	0.94 (0.92, 0.97)	0.001		
Gender (Male vs. Female)	0.67 (0.52, 0.88)	0.004	0.55 (0.27, 1.10)	0.09	0.38 (0.20, 0.72)	0.003
Importance of an attractive appearance			4.46 (1.04, 19.14)	0.04		
Ethnicity	1.34 (1.03, 1.76)	0.03			2.09 (1.12, 3.93)	0.02
Angle of Convexity	0.95 (0.94, 0.96)	0.001	0.53 (0.49, 0.57)	0.001	1.57 (1.50, 1.65)	0.001
Section		0.001				
1 vs. 2	0.55 (0.43, 0.70)	0.001				
Observer Group		0.1		0.19		0.02
Laypeople vs. Patients	0.93 (0.68, 1.27)	0.7	0.53 (0.24, 1.18)	0.12	0.84 (0.43, 1.67)	0.62
Clinicians vs. Patients	0.69 (0.48, 0.99)	0.05	1.07 (0.41, 2.77)	0.90	0.31 (0.13, 0.71)	0.01
Laypeople vs. Clinicians	1.35 (0.95, 1.94)	0.1	0.50 (0.20, 1.25)	0.14	2.74 (1.17, 6.42)	0.02

After adjusting for these effects, significant differences were found between the three groups of observers. The odds of desire for surgery were 69% less for clinicians than for patients in section 2, and greater for laypeople than for clinicians (4-fold in section 2). No differences were detected between laypeople and patients.

A multivariate logistic regression showed no significant differences between the three Classes in the patient group, although the odds of desire for surgery tended to be 50% greater for Classes II and III in relation to I. No difference was detected between Classes II and III (Table 6.6).

Table 6.6 Multivariate mixed logistic regression for binary outcome: desire for surgery (orthognathic patient group)

Description	OR	95% Conf. Interval		P-value
Age	0.97	0.95	0.99	0.003
Gender (Male vs. Female)	0.8	0.54	1.17	0.25
Ethnicity (White vs. non-White)	1.23	0.82	1.84	0.32
Degree of asymmetry of image (mm)	0.99	0.98	1.00	0.12
Observer's skeletal Class (Anteroposterior jaw relationship)				0.12
II vs. I	3.03	1.06	8.70	0.04
III vs. I	2.91	1.01	8.40	0.05
II vs. III	1.04	0.70	1.55	0.84

The facial profile convexity angle 'cut-off' point from which observers desired surgical correction is shown in table 6.7.

Table 6.7 Lower facial convexity 'cut-off' point from which observers' desire surgical correction

Section	Orthognathic patient group (degrees)	Laypeople group (degrees)	Clinician group (degrees)
1	10.4	8.7	9.9
2	-12.5	-7.5	-11.1

6.3.4 Most attractive and least attractive images

The highest rated and thereby most attractive perceived images (CJ, BH, CI, BG and BI) were those with a straight or almost straight profile and the lowest rated images (KG, LG, JR, KF and JS) demonstrate significant degrees of facial profile convexity (Table 6.8).

Table 6.8 Mean observer ratings and confidence intervals, ordered from worse to best rating (b – backwards; f – forwards)

Image	Lower facial profile convexity angle	Mean	95% CI		Median
KG	14° b	1.8	1.7	1.9	2
LG	-16° f	2.3	2.2	2.4	2
JR	12° b	2.4	2.3	2.6	2
JS	-12° f	2.5	2.3	2.6	2
KH	-14° f	2.5	2.4	2.6	2
HP	10° b	2.9	2.7	3.1	3
GN	8° b	3.1	3.0	3.3	3
HQ	-10° f	3.2	3.0	3.3	3
GO	-8° f	3.6	3.5	3.8	4
FI	6° b	3.7	3.5	3.8	4
FJ	-6° f	4.3	4.1	4.4	4
EJ	4° b	4.5	4.3	4.6	4
DL	-4° f	4.5	4.3	4.6	5
DK	4° b	4.6	4.4	4.7	5
EK	-4° f	4.8	4.7	5.0	5
BI	0	5.3	5.1	5.4	5
CI	2° b	5.3	5.2	5.4	5
BH	0	5.4	5.2	5.5	5
CJ	-2° f	5.4	5.3	5.6	6

6.4 Discussion

Physical attractiveness is recognized as an important attribute in psychosocial well-being. The facial profile may be a particular source of concern for some individuals, with a considerably convex or concave profile being a significant reason for patients seeking orthognathic surgery. An anterior or posterior lower facial profile inclination in the sagittal plane is a potentially important determinant of perceived attractiveness and thereby knowledge of perceptions of attractiveness, in addition to average population values, is important for clinicians correcting facial deformities.

6.4.1 Hypothesis testing

The first part of the null hypothesis was that ‘there is no effect of the type or degree/severity of the deviation of the lower facial profile convexity angle on perceived attractiveness and desire for surgery.’ We reject this null hypothesis, as the results of this study found an effect of the type and degree/severity of the deviation of the lower facial profile convexity angle on perceived attractiveness and desire for surgery. The second part of the null hypothesis was that ‘Likewise, there is no difference in the perception of orthognathic patients, laypeople and clinicians.’ We reject this null hypothesis, as the results of this study found a difference in the perceptions of the observer groups.

6.4.2 Influence of the degree of convexity of the image

The angle of profile convexity was found to have a highly significant association with ratings of attractiveness. The mean rating for attractiveness was greater for images with a straight profile in relation to those with any degree of convexity or concavity; no significant differences were found between convex and concave lower facial profiles.

Ratings for attractiveness decreased for every degree increase in the facial profile convexity angle; this effect was slightly more marked for section 1. Ratings decreased more for section 1 in relation to section 2, suggesting that a convex lower facial profile is perceived as the least attractive. This supports previous evidence that Class II profiles are regarded as less attractive than Class III profiles in some western countries (Czarnecki et al., 1993; Michiels and Sather, 1994; Cochrane et al., 1994). A possible explanation is the negative stereotype of the severe Class II individual, often perceived as lacking intelligence.

6.4.3 At what degree of convexity does the discrepancy become so noticeable that patients want (or clinicians or laypeople recommend) surgical correction?

The patient and clinician groups found lower face convexity significantly noticeable and thereby desired surgical correction from an angle of approximately 10 degrees; laypeople found this at approximately 9 degrees. The patient group found lower face concavity significantly noticeable and thereby desired surgical correction from an angle of -12.5 degrees and the clinician group from approximately -11 degrees, whereas the laypeople group found this at -7.5 degrees. Overall, the desire for surgery increased with greater degrees of convexity/concavity.

6.4.4 Influence of the type of convexity of the image

A comparison of the two sections demonstrates which type of convexity appears to be the most noticeable and which creates the greatest desire for surgery. The odds ratio for section 1 vs. 2 was 0.55, which is significant. Effectively, lower facial convexity is slightly less noticeable than concavity.

6.4.5 Influence of observer group and professional status

The mean ratings of attractiveness were significantly different between the three observer groups, results indicating a trend that patients are more critical than laypeople or clinicians. Clinicians will develop enhanced critical faculties as a result of their training but it may be that the very existence of a significant facial profile convexity/concavity will lead to patients developing a greater sensitivity to noticeable differences in facial appearance from the 'ideal'. Previous studies have found significant differences between the perceptions of facial profile attractiveness of orthodontists and maxillofacial surgeons compared with laypeople (Cochrane et al., 1999). Attractiveness studies often use laypeople as observers but seldom use patients. The results of the present investigation, finding that orthognathic patients were more critical than laypeople, suggests that in future studies greater emphasis may be put on evaluating the perceptions of orthognathic patients as opposed to only laypeople.

Comparison of Classes I, II and III in the patient group demonstrated that the most influential variable on rating was the facial profile convexity angle. It was observed that, in relation to skeletal Class I, Classes II and III produced significantly reduced ratings for attractiveness, but no difference was detected between Classes II and III. It appears that all patients found a significant deviation from a straight profile to be less attractive, though the effect on patients with a significant Class II or III deformity was greater, indicating a relationship between the patient’s own facial appearance and their perceptions of attractiveness.

There is evidence that Class II profiles are regarded as less attractive than Class III profiles (Czarnecki et al., 1993; Michiels and Sather, 1994; Cochrane et al., 1999), and that the Class I profile is more attractive than Class II or III (Kerr and O’Donnell, 1990; Phillips et al., 1995; Hönn et al., 2005; Ioi et al., 2007). However, none of these studies used orthognathic patients as evaluators, and they tested sagittal changes in chin position as alteration of facial convexity, i.e. though looking at “profile convexity” they have just really looked at chin deficiency/excess. Arnett et al. (1999) mentioned that many Class II patients with mandibular deficiency also have an element of sagittal maxillary deficiency, i.e. require some maxillary advancement as well as a more substantial mandibular advancement. Such patients have a genuinely convex lower facial profile, not just sagittal chin deficiency.

6.4.6 Desire for surgery

In terms of desire for surgery, observer age had a highly significant effect in section 1, with the odds of desire for surgery decreasing by 5% for each year increase in age of the observer. Observer gender had a highly significant effect in section 2; odds of desire for surgery were 61% less for men. A possible explanation is that the desire for surgery with a concave lower facial profile may be less for men as a 'strong' lower jaw/chin appears to be less of an aesthetic problem for men than women. An effect of ethnicity was observed only in section 2; non-White observers found concave profiles less attractive, with odds of desire for surgery double that of white observers. The effect of the facial profile convexity angle was very significant in both sections. The odds of desire for surgery increased by 60% for each degree increase in the facial profile convexity angle in section 2 and almost doubled in section 1.

The odds of desire for surgery were 69% less for clinicians than for patients in section 2. The odds of desire for surgery were greater for laypeople than for clinicians, 4-fold in section 2. In contrast, in section 1, the odds tended to be less for laypeople than for clinicians although this difference was not significantly different. No differences were detected between laypeople and patients.

In the patient group no significant differences between the three skeletal Classes were found, although the odds of desire for surgery tended to be 50% greater for Classes II and III in relation to I. No difference was detected between Classes II and III.

6.4.7 Most attractive and least attractive images

The highest rated and thereby most attractive perceived images were those with a straight or almost straight profile and the lowest rated images demonstrate significant degrees of facial profile convexity. The overall trend demonstrated that milder degrees of convexity/concavity, e.g. 2 degrees, were rated as more attractive and greater degrees of convexity were rated as progressively less attractive.

6.4.8 Comparison with previous studies

The results of this investigation support previous empirical evidence that mild facial convexity/concavity is compatible with an attractive facial appearance, and a straight profile is 'ideal'. For example, Gonzalez-Ulloa's zero-degree meridian (Gonzalez-Ulloa and Stevens, 1968) is an aesthetic profile line, proposing that soft tissue pogonion should be on this vertical line dropped from soft tissue nasion, perpendicular to the Frankfort Horizontal plane, with subnasale on or close to this line. Holdaway (1983; 1984) described the facial angle as the inferior inside angle in which the facial line (soft tissue nasion to soft tissue pogonion) intersects the Frankfort Horizontal plane. The 'ideal' angle was described as 90-92 ± 7 degrees; a greater angle indicates prominence of soft tissue pogonion; an angle less than 90 degrees indicates retrusion of soft tissue pogonion. Both these analyses are effectively describing a straight profile as the 'ideal'.

However, population studies do not necessarily support the empirical perfectly straight profile as the norm. Legan and Burstone (1980) described the angle of facial convexity for the soft tissue profile; the mean value was estimated to be 12 ± 4 degrees. Worms et al. (1976) provide a value of 11 ± 4 degrees for this same angle, based on a sample of patients of unknown size. Schwarz (1961) advised an angle of 10 degrees for the 'average' profile, Mauchamp and Sassouni (1973) advised an angle of 10-15 degrees and Muzj (1956) approximately 8 degrees. In a longitudinal growth study, Subtelny (1959) found an angle of approximately 16-17 degrees at age 18, with a slight reduction in profile convexity during growth. Bhatia and Leighton's longitudinal growth study (1993) found an angle of 19 ± 6 degrees in men and 17 ± 6 degrees in women at age 18, though they substituted a projected soft tissue nasion as the upper landmark instead of soft tissue glabella. Farkas et al. (1985) found an angle of approximately 16 ± 6 degrees and 14 ± 6 degrees in adult men and women respectively, based on a sample of 232 North American Caucasians, with a gradual reduction in the angle evident from the early teenage years. Interestingly, Farkas et al. (1985) compared their results with sculptures and paintings from classical antiquity, the Renaissance and contemporary art extending throughout the 20th century. These male profiles demonstrate angles of approximately 5-6 ± 6 degrees for antiquity/Renaissance art and approximately 4 ± 3 degrees for contemporary art, compared with the 16 ± 6 degrees of the modern population sample. Conversely, the female profiles of antiquity/Renaissance art demonstrate greater values of approximately 14 ± 3 degrees, compared to 4 ± 3 degrees for contemporary art and 14 ± 6 degrees in the modern population sample. In terms of art, in both men and women there has been a gradual tendency towards a straighter profile over time, though this has been more marked in women, yet the modern population averages in both genders demonstrate angles extending from, approximately, 10 to 20 degrees.

This is important as, in the past, artistic canons were readily adopted by clinicians due to the pressing requirement for aesthetic standards in the rapidly developing field of facial aesthetic and reconstructive surgery, of which orthognathic surgery is a part. Yet artistic canons alone are, to all intents and purposes, idealizations, which do not necessarily represent normative human morphology, and therefore, though useful, are not enough. Objective evidence from normative population samples, such as those provided by the above (Worms et al., 1976; Subtelny, 1959; Bhatia and Leighton, 1993; Farkas et al., 1985), and the results of perceptions of attractiveness studies as presented in this article, provide more useful aesthetic standards for treatment planning in modern orthognathic/craniofacial surgery.

6.5 Conclusions

Convexity of the lower face is perceived as significant at 10 degrees and concavity at –12 degrees; between these values the lower facial profile contour may be deemed within normal limits in terms of observer perception.

The greater the angle of profile convexity past 10 degrees convexity and –12 degrees concavity, the more noticeable it is.

Patients desire treatment from greater than 10 degrees of convexity and –12 degrees of concavity.

The angle of facial profile convexity has a highly significant association with ratings of attractiveness, with a straight profile perceived as most attractive and greater degrees of convexity/concavity deemed less attractive; ratings of attractiveness reduce and desire for surgery increases for every degree change in this angle from a straight profile.

Patients are more critical than laypeople or clinicians, and clinicians are more critical than laypeople. This stresses the importance of using patients as observers, as well as laypeople and clinicians.

Women appear to have a greater desire for correction of a concave lower face as opposed to men.

In relation to skeletal Class I, observers with Classes II and III gave significantly reduced ratings of attractiveness and had greater desire for surgery; there was no difference between observers with Classes II and III.

7 The influence of chin prominence on perceived attractiveness

7.1 Introduction

The chin is an important determinant of facial profile attractiveness (Rosen, 1995). Its prominence is one of the facial characteristics that society tends to associate with an individual's personality. Individuals, particularly men, with a deficient chin may be viewed as 'weak,' whereas a prominent chin is often described as a 'strong' chin, implying strength of personality (Naini, 2011).

Each facial parameter, such as chin prominence, will have an 'average' value or 'norm' for a given population, which is specific for age, gender and ethnicity. Each of these 'norms' will also have a range of variability, with the existence of a facial deformity often resulting from a significant deviation of one or more facial parameters from the accepted norm for a population. At what point does the deviation of a facial parameter move from the limits of the acceptable range of variability into being perceived as a facial deformity?

The magnitude of the deviation, whether it is due to an underlying dentoskeletal discrepancy, the overlying facial soft tissues or a combination of the two, is an important factor in decision-making when jaw surgery may be required. If the magnitude of the discrepancy of a facial parameter is great (for example excessive chin prominence) then the treatment planning decision may be relatively straightforward. However, there are a significant number of patients who are regarded as 'borderline' in terms of need for surgical treatment. In such patients, the decision making process may be transferred from subjective clinical judgement to objective, evidence-based guidance based on data from studies investigating perceptions of facial attractiveness. For example, if the degree of chin prominence is being assessed, it may be found that a large percentage of observers find that greater than *x* mm of sagittal chin prominence is regarded as unattractive and requiring surgical correction. This would provide objective evidence to guide clinicians when planning treatment.

Chin prominence is a potentially important factor in the perception of facial attractiveness. The purpose of this study was to find objective evidence to aid clinicians in planning the treatment of patients requiring sagittal augmentation or reduction genioplasty.

The principle aim of this investigation was to quantitatively evaluate the influence of sagittal chin prominence on perceived attractiveness. In addition, the relationship between degree of chin prominence and attractiveness was recorded to ascertain the range of normal variability, in terms of observer acceptance, and determine the clinically significant threshold value or cut-off point, beyond which the degree of chin prominence is perceived as unattractive and treatment is desired. Finally, the perception of orthognathic patients, clinicians and laypeople were compared for these different variables.

7.2 Subjects and Methods

7.2.1 The Images

Two-dimensional facial profile silhouettes have been routinely used to assess the perceptions of facial profile attractiveness (Barrer and Ghafari, 1985; Johnston et al., 2005a; Ioi et al., 2005).

A facial profile silhouette image was created with computer software (Adobe® Photoshop® CS2 software; Adobe Systems Inc, San Jose, CA). The image was then manipulated using the same computer software to construct an 'ideal' facial profile image with proportions (Naini, 2011) and soft tissue measurements (Farkas et al., 1984;

Farkas et al., 1985; Farkas et al., 1986; Farkas and Kolar, 1987; Farkas, 1994; Naini, 2011) based on currently accepted criteria (see Figures 2.4 and 2.5).

7.2.1.1 Profile image manipulation (incremental)

The chin prominence of the idealised profile image was altered in 2 mm increments from -24 to 12 mm, in order to represent retrusion and protrusion of the chin respectively (Figure 7.1).

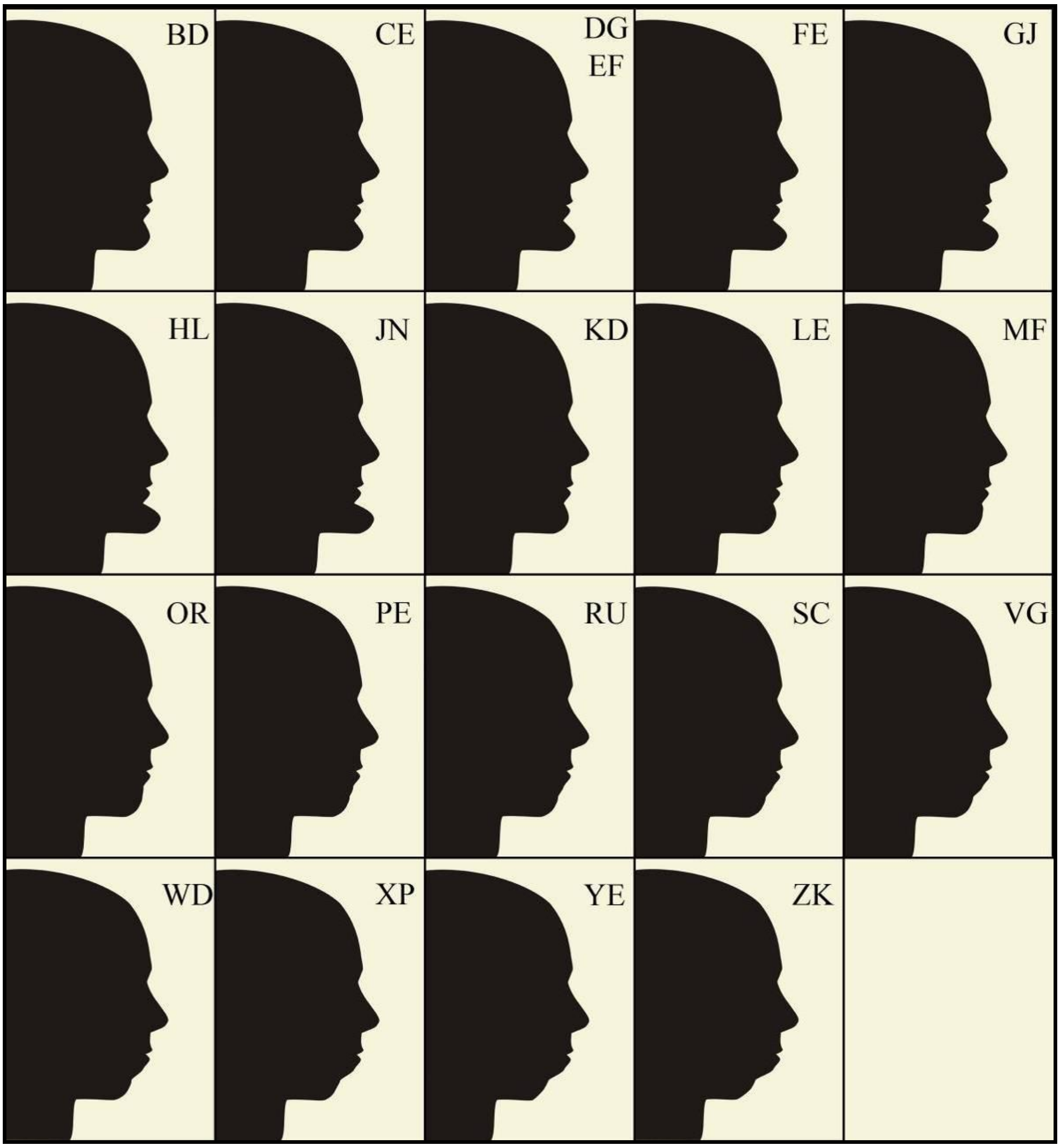

Figure 7.1 Sagittal chin prominence altered in 2mm increments, from -24 to 12mm

7.2.2 The observers, questionnaire and rating method

7.2.2.1 Observers

Based on the results of the pilot study described in section 2.2.4, a total of 185 observers took part in the study, separated into 3 groups (pre-treatment orthognathic patients, laypeople and clinicians) (see Table 2.1).

Selection of the three groups of observers followed the selection criteria described in section 2.2.4.1.

7.2.2.2 Questionnaire

Each observer was given a questionnaire thanking them for agreeing to take part in the research. The observers were asked to provide the following information: age, gender, ethnic origin (White or non-White Caucasian), how would you rate the attractiveness of your facial appearance, and how important do you think it is to have an attractive facial appearance.

The observers rated each facial image using the following scale:

1. Extremely unattractive
2. Very unattractive
3. Slightly unattractive
4. Neither attractive nor unattractive
5. Slightly attractive
6. Very attractive
7. Extremely attractive

In addition, observers were asked whether they would consider surgery to correct the appearance if this was their facial appearance.

The images were placed in random order into Microsoft PowerPoint®. Each image was identified by a randomly assigned double letter in the top right corner of the screen (e.g.

BD). A duplicate of one of the images in each group was used in order to assess intra-examiner reliability. Each observer sat undisturbed in the same room in front of the same computer and 17” flat screen monitor. The presentation and the images were created in such a way that each of the profile silhouette images, when viewed on the 17” flat screen monitor, had the same dimensions as a normal human head, based around an average lower anterior facial height. This would help to reduce the potential effect of image magnification or size reduction on the observer’s perception. Each observer examined the images in the PowerPoint® presentation by pressing the ‘Page Down’ button on the keyboard, in their own time.

7.2.2.3 Rating method

The Likert-type rating scale is largely accepted in the psychology literature as the most useful rating method (Langlois et al., 2000). The seven-point Likert scale described above was used by each observer to rate each image in terms of attractiveness. An example of a section of the questionnaire has been provided (see Figure 2.6).

7.2.3 Statistical analysis

The observer’s ratings were recorded in a Likert scale from 1 to 7. Mixed regression was used to assess the differences in ratings for the three groups (pre-treatment orthognathic patients, laypeople, and clinicians) while adjusting for the concurrent effects of age, gender, ethnicity, self-rating for facial attractiveness, the importance given to an attractive facial appearance, the observer’s anteroposterior jaw relationship (Class I, II or III), the observer’s vertical face height (average, increased or decreased), observer’s facial asymmetry (yes/no) and the degree of sagittal chin prominence of the images. The multivariate regression models are fitted in a stepwise manner, including all those variables that reach a significance below P=0.25 univariately. Given the recognised low power of the relevant test, the benchmark for a significant interaction was set at the 10%

level. The mixed regression uses a multi-level approach to take into account the clustering effect by observer. The model was validated using a logarithmic transformation for the rating scale to assess the effect of departure from normality.

7.3 Results

All the laypeople and the clinicians were skeletal Class I while 96% of the patients were Class II or III. There was no significant difference in perceptions of attractiveness between observer's with Class II and III jaw relationships ($P=0.91$) but they appeared to differ significantly from those with skeletal Class I. When skeletal Class was fitted on the patient group alone no difference was detected between Classes II and III ($P=0.86$).

7.3.1 Reliability analysis

A duplicate of one of the images was used in order to assess intra-examiner reliability. With analysis of variance with random effects for the observers, the variability between observers, for replicated images DG and EF, was highly significant ($P<0.001$): the value of the $F(184,185)$ statistic was 3.03. These results indicate that there was little variation in the intra-observer ratings for these images. The intra-class correlations was $ICC=0.50$ (95% c.i. 0.40 to 0.61) (moderate reliability).

7.3.2 Perceived attractiveness of images

The univariate and multivariate mixed linear regressions for rating are exhibited in tables 7.1 and 7.2.

Table 7.1 Univariate mixed linear regression for rating

Description	Coef. – Interval	P value
Age	0.01 (0.00, 0.02)	0.004
Gender (Male vs. Female)	0.05 (-0.16, 0.27)	0.64
Ethnicity (White vs. non-White)	0.07 (-0.14, 0.28)	0.51
Handedness (Left vs. Right)	0.06 (-0.30, 0.41)	0.75
Self-rating of appearance	-0.08 (-0.24, 0.10)	0.38
Importance of an attractive appearance	-0.11 (-0.34, 0.11)	0.33
Observer's skeletal Class (Anteroposterior jaw relationship)		0.06
II vs. I	-0.18 (-0.44, 0.08)	0.19
III vs. I	-0.30 (-0.57, -0.04)	0.03
II vs. III	0.13 (-0.20, 0.45)	0.45
Observer's skeletal Class (II and III vs. I)	-0.24 (-0.45, -0.03)	0.03
Observer's vertical lower anterior face height	0.28 (-0.05, 0.62)	0.10
Chin prominence (deviation in mm)	-0.11 (-0.12, -0.11)	0.001
Chin prominence (Protrusion vs. 0 vs. Retrusion)		0.001
Normal vs. Chin retrusion	2.39 (2.20, 2.58)	0.001
Chin protrusion vs. Chin retrusion	-0.60 (-0.69, -0.52)	0.001
Normal vs. Chin protrusion	2.99 (2.80, 3.19)	0.001
Observer Group		0.03
Laypeople vs. Patients	0.29 (0.07, 0.52)	0.01
Clinicians vs. Patients	0.05 (-0.23, 0.33)	0.71
Laypeople vs. Clinicians	0.24 (-0.04, 0.52)	0.10

Table 7.2 Multivariate mixed linear regression for rating

	Chin retrusion (negative+0)				Chin protrusion (Positive+0)			
Rating	Coef.	95% C.I		P	Coef.	95% C.I		P
Age	0.004	-0.005	0.01	0.35	0.01	0.003	0.02	0.01
Self-rating of appearance	-0.21	-0.49	0.07	0.15	-0.24	-0.51	0.02	0.07
Chin prominence	-0.15	-0.16	-0.14	0.001	-0.30	-0.31	-0.28	0.001
Observer Group				0.22				0.01
Laypeople vs. Patients	0.26	-0.03	0.55	0.08	0.40	0.13	0.68	0.004
Clinicians vs. Patients	0.15	-0.22	0.52	0.42	0.17	-0.18	0.52	0.34
Laypeople vs. Clinicians	0.11	-0.20	0.42	0.49	0.24	-0.06	0.53	0.12

Based on the results, the most significant factor influencing rating is the degree of sagittal chin prominence. The effect of chin prominence is more marked when the chin is protrusive (forward, positive) than when is retrusive (backward, negative). Ratings decrease, on average, by 0.30 of a level of the Likert scale (95% c.i. 0.28 to 0.31) for each unit increase in chin protrusion and by 0.15 of a level of the Likert scale (95% c.i.

0.14 to 0.16) for each unit chin retrusion. In both cases, the difference begins only after 2 units (i.e. 4 mm) of change.

Age influences rating of images with forward prominence only (P=0.01). Similarly, an effect of the observers self-rating of their own attractiveness is borderline significant for images with forward prominence only (P=0.07).

After adjusting for these effects, an effect of observer group was found only for rating of images with chin protrusion. On average, laypeople gave a higher rating for attractiveness than patients when rating images with chin protrusion (coeff=0.40; 95% ci 0.13 to 0.68; P=0.004).

A multivariate linear regression was fitted for the group of patients, in order to compare the ratings for the different skeletal Classes. No significant differences in the mean ratings were found between the different skeletal Classes (Table 7.3).

Table 7.3 Multivariate mixed linear regression for rating (orthognathic patient group)

	Chin retrusion (negative+0)				**Chin protrusion (Positive+0)**			
Rating	**Coef.**	**95% C.I.**		**P**	**Coef.**	**95% C.I.**		**P**
Chin Prominence	-0.15	-0.15	-0.14	0.001	-0.28	-0.30	-0.26	0.001
Observer's skeletal Class				0.47				0.44
II vs. I	-0.46	-1.31	0.40	0.30	-0.19	-1.10	0.71	0.67
III vs. I	-0.54	-1.39	0.32	0.22	-0.39	-1.30	0.52	0.40
II vs. III	0.08	-0.25	0.41	0.64	0.20	-0.16	0.56	0.27

7.3.3 Desire for surgery

The univariate mixed logistic regression for the binary outcome, desire for surgery, is demonstrated in table 7.4 and the multivariate logistic regression in table 7.5.

Table 7.4 Univariate mixed logistic regression for binary outcome: desire for surgery

Description	OR – Interval	P value
Age	0.98 (0.97, 0.99)	0.001
Gender (Male vs. Female)	0.76 (0.56, 1.04)	0.09
Ethnicity (White vs. non-White)	0.96 (0.71, 1.30)	0.79
Handedness (Left vs. Right)	0.83 (0.50, 1.39)	0.48
Self-rating of appearance	1.26 (0.92, 1.72)	0.15
Importance of an attractive appearance	1.24 (0.89, 1.73)	0.20
Observer's skeletal Class (Anteroposterior jaw relationship)		0.83
II vs. I	1.08 (0.73, 1.59)	0.71
III vs. I	0.93 (0.63, 1.38)	0.72
II vs. III	1.16 (0.72, 1.88)	0.55
Observer's skeletal Class (II and III vs. I)	1.00 (0.74, 1.36)	0.99
Observer's vertical lower anterior face height	1.27 (0.78, 2.08)	0.34
Chin Prominence (Amount mm)	1.23 (1.21, 1.25)	0.001
Number of mm (Protrusion vs. 0 vs. Retrusion)		0.001
Normal vs. Chin retrusion	0.05 (0.03, 0.08)	0.001
Chin protrusion vs. Chin retrusion	2.39 (2.02, 2.83)	0.001
Normal vs. Chin protrusion	0.02 (0.01, 0.04)	0.001
Observer Group		0.91
Laypeople vs. Patients	1.06 (0.76, 1.48)	0.74
Clinicians vs. Patients	1.09 (0.72, 1.64)	0.69
Laypeople vs. Clinicians	0.97 (0.65, 1.47)	0.90

Table 7.5 Multivariate mixed logistic regression for binary outcome: desire for surgery

	Chin retrusion (negative+0)				Chin protrusion (Positive+0)			
Desire for surgery	OR	95% C.I		P	OR	95% C.I		P
Age	0.96	0.93	0.98	0.001	0.96	0.93	0.98	0.001
Gender (Male vs. Female)	0.37	0.19	0.72	0.003	1.04	0.57	1.89	0.90
Chin prominence	1.41	1.37	1.45	0.001	1.90	1.75	2.06	0.001
Observer Group				0.12				0.26
Laypeople vs. Patients	2.21	1.03	4.73	0.04	1.43	0.72	2.85	0.31
Clinicians vs. Patients	1.75	0.71	4.33	0.23	1.97	0.87	4.50	0.11
Laypeople vs. Clinicians	1.26	0.53	3.02	0.60	0.73	0.33	1.60	0.43

The most important factor influencing the likelihood of desire for surgery was the extent of chin prominence. The effect of sagittal chin prominence was more marked with chin protrusion (forward, positive) than retrusion (backward, negative). The odds of wanting surgery increased by 41% (OR=1.41; 95% ci 1.37 to 1.45; P=0.001) for each unit increase in the chin retrusion and almost doubled (OR=1.90; 95% ci 1.75 to 2.06; P=0.001) for each extra unit in the chin protrusion.

Observer age influenced the likelihood of desire for surgery. The odds of wanting surgery decreased by 4% for each year increase in the age of the observer (OR=0.96; 95% c.i. 0.93 to 0.98; P=0.001). This effect was similar for chin protrusion and retrusion. An effect of observer gender was found for images with chin retrusion only; the odds of wanting surgery were 63% less for men in relation to women (OR=0.37; 95% c.i. 0.19 to 0.72; P=0.003). No significant effect of observer group on the likelihood of desire for surgery was found.

The extent of sagittal chin prominence above which observers began to desire surgery depended on whether the deviation was protrusive or retrusive, but did not differ much between the groups of observers. For chin retrusion, the values from which surgery was desired were: -10.9mm for patients, -10.3mm for laypeople and -11.2mm for clinicians. For chin prominence, the values from which surgery was desired were: 6.3mm for patients, 6.1mm for laypeople and 5.8mm for clinicians.

7.3.4 Most attractive and least attractive images

The highest rated and thereby most attractive perceived image was BD, representing the idealised facial profile with soft tissue pogonion on the true vertical line (Table 7.6). Other highly rated images exhibited minor degrees of chin retrusion (KD, LE, MF) or very minor chin prominence (CE). The lowest rated images (JN, ZK) demonstrate the most severe degrees of chin protrusion and retrusion.

Table 7.6 Mean observer ratings and confidence intervals, ordered from worse to best rating (positive values represent chin protrusion and negative values represent chin retrusion)

Image	Chin prominence (mm)	Mean	Std. Err	95% Conf. Interval		Median
JN	12	1.36	0.05	1.26	1.46	1
ZK	-24	1.75	0.07	1.62	1.88	1
GJ	8	1.77	0.07	1.63	1.90	2
HL	10	1.89	0.07	1.74	2.03	2
XP	-20	1.96	0.07	1.82	2.11	2
YE	-22	2.02	0.07	1.87	2.16	2
FE	6	2.12	0.08	1.97	2.27	2
WD	-18	2.20	0.08	2.05	2.36	2
VG	-16	2.32	0.08	2.16	2.48	2
SC	-14	2.57	0.08	2.41	2.73	3
DG	4	2.63	0.08	2.47	2.79	3
RU	-12	2.74	0.08	2.57	2.91	3
EF	4	2.90	0.09	2.71	3.08	3
PE	-10	3.15	0.07	3.00	3.29	3
OR	-8	3.70	0.09	3.51	3.89	4
MF	-6	3.84	0.08	3.68	4.00	4
CE	2	3.90	0.10	3.70	4.11	4
LE	-4	4.49	0.08	4.33	4.65	4
KD	-2	4.94	0.09	4.75	5.13	5
BD	0	5.36	0.08	5.20	5.53	5

7.4 Discussion

The facial profile may be a particular source of concern for some individuals, with a considerably prominent or retrusive chin being a significant reason for patients seeking orthognathic surgery/genioplasty. The appearance of the chin in profile view is a potentially important determinant of perceived attractiveness and thereby knowledge of perceptions of attractiveness, in addition to average population values, is important for clinicians correcting facial deformities (Naini, 2011).

A large number of studies have been undertaken to assess the psychological factors involved in perceptions of facial attractiveness (Langlois et al., 2000). However, the purpose of the present investigation was to provide clinically relevant data by evaluating the perceptions of attractiveness for chin prominence, in order to provide objective evidence to guide clinicians involved in the treatment planning of patients requiring orthognathic surgery.

7.4.1 Hypothesis testing

The first part of the null hypothesis was that ‘there is no effect of the type or degree/severity of the deviation of chin prominence on perceived attractiveness and desire for surgery.’ We reject this null hypothesis, as the results of this study found an effect of the type and degree/severity of the deviation of chin prominence on perceived attractiveness and desire for surgery. The second part of the null hypothesis was that ‘Likewise, there is no difference in the perception of orthognathic patients, laypeople and clinicians.’ We reject this null hypothesis for ratings of attractiveness of images with chin prominence only, as the results of this study found a difference in the perceptions of the observer groups. We do not reject the null hypothesis in terms of ratings of attractiveness of images with chin retrusion or in terms of desire for surgery, as no significant inter-group differences were found.

7.4.2 Influence of the degree and type of chin prominence of the image

The most important factor influencing ratings of attractiveness was the degree of sagittal chin prominence. The effect of chin prominence was more marked when the chin was protrusive than when it was retrusive. Ratings decreased, on average, by 0.30 of a level of the Likert scale for each unit increase in chin protrusion and by 0.15 of a level of the Likert scale for each unit chin retrusion. In both cases, the difference began only after 2 units (i.e. 4 mm) of change.

Observer age influenced ratings of images with chin protrusion only. Similarly, an effect of the observers self-rating of their own attractiveness was borderline significant for images with chin protrusion only (P=0.07).

A multivariate linear regression was fitted for the group of patients, in order to compare the ratings for the different skeletal Classes. No significant differences in the mean ratings were found between the different skeletal Classes.

7.4.3 At what degree of chin prominence does the chin profile become so noticeable that patients want (or clinicians or laypeople recommend) surgical correction?

The extent of sagittal chin prominence above which observers began to desire surgery depended on whether the chin deviation was protrusive or retrusive, but did not differ significantly between the groups of observers. For chin retrusion, the values from which surgery was desired were approximately -11mm for patients and clinicians, and -10mm for laypeople. For chin prominence, the values from which surgery was desired were approximately 6mm for all three observer groups.

7.4.4 Influence of observer group and professional status

Previous studies have found significant differences between the perceptions of facial profile attractiveness of orthodontists and maxillofacial surgeons compared with laypeople (Cochrane et al., 1999). However, in the present study an effect of observer group was found only for ratings of images with chin protrusion, with laypeople on average giving a higher rating for attractiveness than patients when rating images with chin protrusion. No significant effect of observer group on the likelihood of desire for surgery was found.

7.4.5 Desire for surgery

The most important factor influencing the likelihood of desire for surgery was the extent of chin prominence. The effect of sagittal chin prominence was more marked with chin protrusion than retrusion. The odds of wanting surgery increased by 41% for each unit increase in the chin retrusion and almost doubled for each extra unit in the chin protrusion. Observer age influenced the likelihood of desire for surgery. The odds of wanting surgery decreased by 4% for each year increase in the age of the observer. This effect was similar for chin protrusion and retrusion. An effect of observer gender was found for images with chin retrusion only; the odds of wanting surgery were 63% less for men in relation to women.

7.4.6 Most attractive and least attractive images

The highest rated and thereby most attractive perceived image was BD, representing the idealised facial profile with soft tissue pogonion on the true vertical line (Table 8). Other highly rated images exhibited minor degrees of chin retrusion (KD, LE, MF) or very minor chin prominence (CE). The lowest rated and thereby least attractive images (JN, ZK) demonstrate the most severe degrees of chin protrusion and retrusion. The overall trend demonstrates that milder degrees of chin retrusion and protrusion were rated as more attractive and greater degrees of deviation were rated as progressively less attractive, though the tendency was for chin protrusion to be perceived as less attractive than retrusion.

7.4.7 Comparison with previous studies

There is previous evidence that Class II profiles are regarded as less attractive than Class III profiles in some western countries (Czarnecki et al., 1993; Michiels and Sather, 1994; Cochrane et al., 1999), but the results of the present study do not provide confirmation, as overall chin protrusion appeared to be less attractive than chin retrusion.

There is also evidence that the Class I profile is more attractive than Class II or Class III profiles (Phillips et al., 1995; Kerr & O'Donnell, 1990; Hönn et al., 2005; Ioi et al., 2007). The results of the present study confirm this, as the 'ideal' orthognathic (straight) profile, with soft tissue pogonion on the true vertical line (image BD), was rated as the most attractive image. Interestingly, in a Japanese population, Ioi et al., (2007) found that although raters tended to choose Class II profiles as more acceptable than Class III profiles for both males and females, patients with Class III profiles tended to seek surgical orthodontic treatment more often. The results of the present study demonstrate that although chin deviations from the 'ideal' are noticeable from approximately 4mm protrusion or retrusion, surgery is desired with relatively smaller protrusive deviations (from ~6mm) compared to retrusive deviations (from ~10mm).

The results of this investigation support previous empirical evidence that mild chin deviation in the sagittal plane is compatible with an attractive facial appearance, and an orthognathic profile is 'ideal'. For example, Gonzalez-Ulloa's zero-degree meridian (1968) is an aesthetic profile line, proposing that soft tissue pogonion should be on this vertical line dropped from soft tissue nasion, perpendicular to the Frankfort Horizontal plane, with subnasale on or close to this line.

Objective evidence from normative population samples (Subtelny, 1959; Worms et al., 1976; Farkas et al., 1985; Bhatia and Leighton, 1993) demonstrates that the angle of soft tissue profile convexity of the lower face tends to be with the chin/lower jaw slightly retrusive; none of the normative population data demonstrates chin protrusion or a Class III profile as within normal limits. Such population data corroborates the results of the present study, in that chin protrusion appears to be less attractive and also leads to a greater desire for surgical correction than chin retrusion. However, it contradicts previous findings that Class II profiles are regarded as less attractive than Class III profiles (Czarnecki et al., 1993; Michiels and Sather, 1994; Cochrane et al., 1999).

7.5 Conclusions

The understanding of ideal morphological and relative positional relationships of individual facial components, such as the sagittal prominence of the chin, is vital for correct treatment planning. From the results of this study, it is recommended that in treatment planning to alter the sagittal prominence of the chin in an individual with an otherwise normal soft tissue facial profile, an 'ideal' sagittal position with soft tissue pogonion on or just behind a true vertical line through subnasale may be used, although chin retrusion or protrusion up to 4mm is essentially unnoticeable. Surgery is desired from protrusions of greater than 6 mm and retrusions greater than 10mm. What is important is that the overall direction of aesthetic opinion appears to be the same for all the observer groups, i.e. the greater the retrusion or prominence of the chin, the less attractive the perceived attractiveness and the greater the desire for surgical correction.

8 The influence of mandibular prominence on perceived attractiveness

8.1 Introduction

Pleasing facial profile aesthetics result from relative harmony between the morphology and prominence of the various facial structures observed in profile view. Of these structures, the sagittal prominence of the mandible is an important determinant of facial profile attractiveness (Johnston et al., 2005a; Kuroda et al., 2009).

Each facial parameter, such as mandibular prominence, will have an 'average' value or 'norm' for a given population, which is specific for age, gender and ethnicity. Each of these 'norms' will also have a range of variability, with the existence of a facial deformity often resulting from a significant deviation of one or more facial parameters from the accepted norm for a population. It is important to know at what point the deviation of a facial parameter moves from the limits of the acceptable range of variability into being perceived as a facial deformity.

The magnitude of the deviation, whether it is due to an underlying dentoskeletal discrepancy, the overlying facial soft tissues or a combination of the two, is an important factor in decision-making when jaw surgery may be required. If the magnitude of the discrepancy of a facial parameter is great (for example excessive mandibular prominence) then the treatment planning decision may be relatively straightforward. However, there are a significant number of patients who are regarded as 'borderline' in terms of need for surgical treatment. In such patients, the decision making process may be transferred from subjective clinical judgement to objective, evidence-based guidance based on data from studies investigating perceptions of facial attractiveness (Naini et al., 2008). For example, if the degree of mandibular prominence is being assessed, it may be found that a large percentage of observers find that greater than *x* mm of sagittal mandibular prominence is regarded as unattractive and requiring surgical correction. This would provide objective evidence to guide clinicians when planning treatment.

The principle aim of this investigation was to quantitatively evaluate the influence of sagittal mandibular prominence on perceived attractiveness to find objective evidence to aid clinicians in planning the treatment of patients requiring orthognathic surgery. In addition, the relationship between degree of mandibular prominence and attractiveness was recorded to ascertain the range of normal variability, in terms of observer acceptance, and determine the clinically significant threshold value or cut-off point, beyond which the degree of mandibular prominence is perceived as unattractive and treatment is desired. Finally, the perception of orthognathic patients, clinicians and laypeople were compared for these different variables.

8.2 Subjects and Methods

8.2.1 The Images

Two-dimensional facial profile silhouettes have been routinely used to assess the perceptions of facial profile attractiveness (Barrer and Ghafari, 1985; Johnston et al., 2005a; Ioi et al., 2005).

A facial profile silhouette image was created with computer software (Adobe® Photoshop® CS2 software; Adobe Systems Inc, San Jose, CA). The image was then manipulated using the same computer software to construct an ‘ideal’ facial profile image with proportions (Naini, 2011) and soft tissue measurements (Farkas et al., 1984; Farkas et al., 1985; Farkas et al., 1986; Farkas and Kolar, 1987; Farkas, 1994; Naini, 2011) based on currently accepted criteria (see Figures 2.4 and 2.5).

Contrary to previous studies using cropped profile silhouettes (Johnston et al., 2005) or photographs (Kuroda et al., 2009), it was decided to display the complete profile silhouette image. Cropping the neck would lead to changes in the submental length (Johnston et al., 2005a; Kuroda et al., 2009), whereas in the present study the submental length remained constant throughout the images. It may be reasonable to argue that using the entire profile in this study created a more realistic image, particularly for non-clinical observers.

8.2.1.1 Profile image manipulation (incremental)

The mandibular prominence of the idealised profile image was altered in 2 mm increments from -16 to 12 mm, in order to represent retrusion and protrusion of the lower jaw respectively (Figure 8.1).

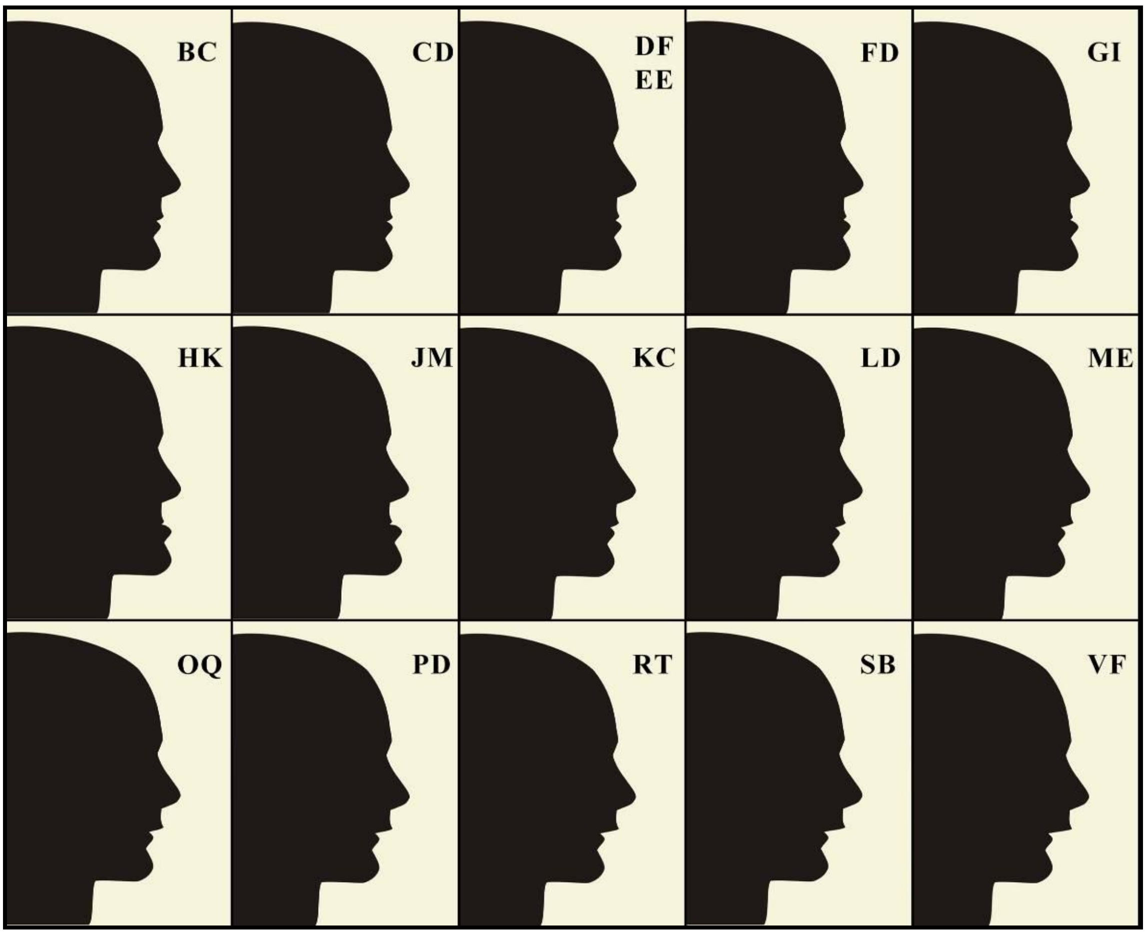

Figure 8.1 Sagittal mandibular prominence altered in 2 mm increments, from -16 to 12 mm

8.2.2 The observers, questionnaire and rating method

8.2.2.1 Observers

Based on the results of the pilot study described in section 2.2.4, a total of 185 observers took part in the study, separated into 3 groups (pre-treatment orthognathic patients, laypeople and clinicians) (see Table 2.1).

Selection of the three groups of observers followed the selection criteria described in section 2.2.4.1.

8.2.2.2 Questionnaire

Each observer was given a questionnaire thanking them for agreeing to take part in the research. The observers were asked to provide the following information: age, gender, ethnic origin (White or non-White Caucasian), how would you rate the attractiveness of your facial appearance, and how important do you think it is to have an attractive facial appearance.

The observers rated each facial image using the following scale:

1. Extremely unattractive
2. Very unattractive
3. Slightly unattractive
4. Neither attractive nor unattractive
5. Slightly attractive
6. Very attractive
7. Extremely attractive

In addition, observers were asked whether they would consider surgery to correct the appearance if this was their facial appearance.

The images were placed in random order into Microsoft PowerPoint®. Each image was identified by a randomly assigned double letter in the top right corner of the screen (e.g.

BC). A duplicate of one of the images in each group was used in order to assess intra-examiner reliability. Each observer sat undisturbed in the same room in front of the same computer and 17” flat screen monitor. The presentation and the images were created in such a way that each of the profile silhouette images, when viewed on the 17” flat screen monitor, had the same dimensions as a normal human head, based around an average lower anterior facial height. This would help to reduce the potential effect of image magnification or size reduction on the observer’s perception. Each observer examined the images in the PowerPoint® presentation by pressing the ‘Page Down’ button on the keyboard, in their own time.

8.2.2.3 Rating method

The Likert-type rating scale is largely accepted in the psychology literature as the most useful rating method (Langlois et al., 2000). The seven-point Likert scale described above was used by each observer to rate each image in terms of attractiveness. An example of a section of the questionnaire has been provided (see Figure 2.6).

8.2.3 Statistical analysis

The observer’s ratings were recorded in a Likert scale from 1 to 7. Mixed regression was used to assess the differences in ratings for the three groups (pre-treatment orthognathic patients, laypeople, and clinicians) while adjusting for the concurrent effects of age, gender, ethnicity, self-rating for facial attractiveness, the importance given to an attractive facial appearance, the observer’s anteroposterior jaw relationship (Class I, II or III), the observer’s vertical face height (average, increased or decreased), observer’s facial asymmetry (yes/no) and the degree of mandibular prominence i.e. protrusion [mandible forward in position, in mm] or retrusion [mandible backward in position, in mm]. The multivariate regression models are fitted in a stepwise manner, including all those variables that reach a significance below P=0.25 univariately. Given the recognised low power of the relevant test, the benchmark for a significant interaction was set at the 10% level. The mixed regression uses a multi-level approach to take into account the clustering effect by observer. The model was validated using a logarithmic transformation for the rating scale to assess the effect of departure from normality.

8.3 Results

All the laypeople and the clinicians were skeletal Class I while 96% of the patients were Class II or III. There was no significant difference in perceptions of attractiveness between observer's with Class II and III jaw relationships ($P=0.91$) but they appeared to differ significantly from those with skeletal Class I. When skeletal Class was fitted on the patient group alone no difference was detected between Classes II and III ($P=0.86$).

8.3.1 Reliability analysis

A duplicate of one of the images was used in order to assess intra-examiner reliability. With analysis of variance with random effects for the observers, the variability between observers, for replicated images DF and EE, was highly significant ($P<0.001$): the value of the $F(182,183)$ statistic was 4.3. These results indicate that there was not much variation in the intra-observer ratings for these images. The intra-class correlations was ICC=0.62 (95% c.i. 0.53 to 0.71), representing good reliability.

8.3.2 Perceived attractiveness of images

The univariate and multivariate mixed linear regressions for rating are exhibited in tables 8.1 and 8.2.

Table 8.1 Univariate mixed linear regressions for rating

Description	Coef.	95% CI		P-value
Age	0.00	0.00	0.01	0.47
Gender (Male vs. Female)	-0.17	-0.35	0.02	0.07
Ethnicity (White vs. non-White)	-0.04	-0.22	0.15	0.70
Handedness (Left vs. Right)	0.06	-0.25	0.37	0.70
Self-rating of appearance	0.08	-0.11	0.27	0.41
Importance of an attractive appearance	-0.17	-0.37	0.02	0.08
Observer's skeletal Class (Anteroposterior jaw relationship)				0.01
Class II vs. I	-0.16	-0.39	0.06	0.16
Class III vs. I	-0.34	-0.57	-0.11	0.004
Class I vs. II/III	0.25	0.07	0.43	0.01
Class I vs. II/III (for patients only)	0.32	-0.38	1.02	0.37
Observer's vertical lower anterior face height	-0.16	-0.46	0.13	0.27
Asymmetry (2 vs. 1)	-0.02	-0.40	0.36	0.92
Type of mandibular deviation (Protrusion vs. 0 vs. Retrusion)				0.001
Normal vs. Retrusion	1.83	1.65	2.02	0.001
Protrusion vs. Retrusion	-0.86	-0.95	-0.77	0.001
Protrusion vs. Normal	-2.70	-2.90	-2.50	0.001
Amount of Deviation (mm)	-0.20	-0.20	-0.19	0.001
Observer Group				0.02
Laypeople vs. Patients	0.27	0.07	0.47	0.01
Clinicians vs. Patients	0.17	-0.07	0.42	0.16
Clinicians vs. Laypeople	-0.10	-0.34	0.14	0.43

Table 8.2 Multivariate mixed linear regression model for rating

Description	Coef.	95% CI		P-value
Gender (Male vs. Female)	-0.14	-0.32	0.04	0.13
Importance of an attractive appearance	-0.15	-0.35	0.05	0.14
Amount of deviation from normal (mm)	-0.20	-0.20	-0.19	0.001
Type of mandibular deviation				0.001
Normal (zero) vs. Retrusion	1.83	1.65	2.02	0.001
Protrusion vs. Retrusion	-0.86	-0.95	-0.77	0.001
Protrusion vs. Normal	-2.70	-2.89	-2.51	0.001
Observer Group				0.05
Laypeople vs. Patients	0.24	0.04	0.43	0.02
Clinicians vs. Patients	0.19	-0.05	0.43	0.13
Clinicians vs. Laypeople	-0.05	-0.30	0.20	0.70

On multivariate analysis the only variable that is found to have a significant effect on rating is the degree and type of mandibular prominence. The mean rating decreased by 0.20 of a level of the Likert scale for each 1 mm increase in the deviation in relation to the normal (95% c.i. -0.20 to -0.19; $P<0.001$). Analysis of the entire dataset demonstrated that the mean rating for the 'Normal' image (i.e. image BC, with soft tissue pogonion on the true vertical line) was 1.83 levels of the Likert scale (95% c.i. 1.65 to 2.02; $P<0.001$) greater than for those images with negative deviation (mandibular retrusion) and 2.7 levels of the Likert scale greater than for those images with positive deviation (mandibular protrusion). The mean rating for images with positive deviation was 0.86 of a level of the Likert scale less than for images with negative deviation.

After adjusting for this effect, a significant difference between the observer groups was found ($P=0.05$). Laypeople gave on average 0.24 of a level of the Likert scale (95% c.i. 0.04 to 0.43; $P<0.02$) greater rating than patients. No significant differences are found between clinicians and patients ($P=0.13$) or clinicians and laypeople ($P=0.70$).

If the observer's skeletal Class is included in the model, considering just the group of patients, we obtain the table shown below (Table 8.3). The most influential variable on rating was the amount of mandibular prominence. The ratings decreased by 0.21 of a level of the Likert scale for each unit increase in the deviation (unit deviation) in the mandible in relation to normal ($P<0.001$). Although there was a tendency for skeletal Classes II and III patients to give lower ratings, no significant differences in the rating between the different skeletal Classes were detected ($P=0.20$).

Table 8.3 Multivariate mixed linear regression for rating (orthognathic patient group)

Rating	Coef.	95% Conf. Interval		P-value
Amount of mandibular deviation (mm)	-0.21	-0.22	-0.19	0.001
Observer's skeletal Class				0.20
II vs. I	-0.24	-0.94	0.47	0.51
III vs. I	-0.42	-1.12	0.30	0.25
III vs. II	-0.18	-0.41	0.05	0.13

8.3.3 Desire for surgery

The univariate mixed logistic regression for the binary outcome, desire for surgery, is demonstrated in table 8.4 and the multivariate logistic regression in table 8.5.

Table 8.4 Univariate mixed logistic regression for binary outcome: desire for surgery

Description	OR	95% CI		P-value
Age	0.99	0.98	1.00	0.004
Gender (Male vs. Female)	1.30	1.01	1.67	0.05
Ethnicity (White vs. non-White)	1.17	0.91	1.50	0.22
Handedness (Left vs. Right)	0.91	0.59	1.38	0.65
Self-rating of appearance	1.01	0.78	1.32	0.91
Importance of an attractive appearance	1.28	0.97	1.67	0.08
Observer's skeletal Class (Anteroposterior jaw relationship)				0.44
II vs. I	1.09	0.79	1.50	0.59
III vs. I	1.24	0.89	1.71	0.20
Observer's skeletal Class (II and III vs. I) (patients only)	0.34	0.09	1.32	0.12
Observer's vertical lower anterior face height	0.89	0.59	1.33	0.57
Amount of mandibular prominence (mm)	1.45	1.40	1.49	0.001
Number of mm (Protrusion vs. 0 vs. Retrusion)				0.001
Retrusion vs. Normal	18.1	10.0	32.6	0.001
Protrusion vs. Retrusion	2.9	2.4	3.4	0.001
Protrusion vs. Normal	52.13	28.69	94.7	0.001
Observer Group				0.57
Laypeople vs. Patient	0.94	0.71	1.24	0.66
Clinician vs. Patient	0.83	0.59	1.17	0.29
Clinician vs. Laypeople	0.88	0.63	1.24	0.48

OR, Odds ratio

Table 8.5 Multivariate mixed logistic regression for binary outcome: desire for surgery

	Negative deviation (retrusion)				Positive deviation (protrusion)			
Description	**OR**	**95% CI**		**P-value**	**OR**	**95% CI**		**P-value**
Age	0.97	0.95	1.00	0.02	0.96	0.93	0.99	0.01
Gender (Male vs. Female)	1.55	0.85	2.81	0.15	2.2	1.01	4.76	0.05
Importance of an attractive appearance	1.26	0.66	2.40	0.49	2.8	1.21	6.62	0.02
Amount of prominence (mm)	1.72	1.62	1.82	0.001	2.0	1.76	2.18	0.001
Observer Group				0.82				0.02
Laypeople vs. Patient	0.95	0.48	1.89	0.89	2.2	0.90	5.38	0.08
Clinician vs. Patient	1.23	0.54	2.80	0.62	0.54	0.19	1.52	0.24
Clinician vs. Laypeople	1.29	0.58	2.90	0.53	0.24	0.09	0.68	0.01

OR, Odds ratio

The univariate analysis (Table 8.4) demonstrates that the odds of desire for surgery increased 3-fold for a positive deviation (protrusion) in relation to no deviation or negative deviation (retrusion). On multivariate logistic regression (Table 8.5), the most important variables influencing desire for surgery were the degree of mandibular prominence and age, followed by gender and consideration of the importance of an attractive appearance.

The odds of desire for surgery:

- essentially doubled for each mm change in the deviation of the mandible from normal (the odds increased by 72% for negative deviation images)
- decreased by 3% (negative deviations) and 4% (positive deviations) for each year increase in age of the observer.
- doubled for men in relation to women, when looking at images with protrusions (OR=2.2).
- increased almost 3-fold (OR=2.8) when looking at protrusions for those who thought attractiveness was very important.

After adjusting for these effects, a significant difference between the observers groups was found when looking at protrusions. In this case, the odds of wanting surgery were 76% less for clinicians in relation to laypeople. In relation to patients, the odds of wanting surgery were twice as large for laypeople, although this difference was only borderline significant.

Mandibular retrusion became noticeable at -4mm, and mandibular protrusion became noticeable at 2mm. The results were the same for the three observer groups. The extent of sagittal mandibular prominence above which observers began to desire surgery depended on whether the deviation was protrusive or retrusive, but did not differ much between the groups of observers. For mandibular retrusion, the values from which surgery was desired were: -8.3mm for patients, -9mm for laypeople and -8.4mm for clinicians. For mandibular prominence, the values from which surgery was desired were: 3.4mm for patients, 3.1mm for laypeople and 4.7mm for clinicians.

8.3.4 Most attractive and least attractive images

The highest rated and thereby most attractive perceived image was BC, representing the idealised facial profile with soft tissue pogonion on the true vertical line (Table 8.6). Other highly rated images exhibited minor degrees of lower jaw retrusion (KC, LD) or very minor lower jaw prominence (CD). The lowest rated images (JM, HK, VF) demonstrate the most severe degrees of lower jaw protrusion and retrusion.

Table 8.6 Mean observer ratings and confidence intervals, ordered from worse to best rating (positive values represent mandibular protrusion and negative values represent mandibular retrusion)

Image	Mandibular prominence (mm)	Mean	95% CI		Median
JM	12	1.7	1.5	1.8	2
HK	10	1.8	1.7	2.0	2
VF	-16	2.0	1.9	2.1	2
GI	8	2.1	2.0	2.3	2
SB	-14	2.4	2.2	2.5	2
FD	6	2.5	2.3	2.6	2
RT	-12	2.7	2.5	2.8	3
EE	4	2.8	2.6	2.9	3
PD	-10	2.8	2.6	2.9	3
DF	4	2.9	2.8	3.0	3
OQ	-8	3.4	3.2	3.6	3
ME	-6	4.0	3.9	4.2	4
CD	2	4.0	3.9	4.2	4
LD	-4	4.9	4.7	5.0	5
KC	-2	5.3	5.1	5.4	5
BC	0	5.3	5.2	5.5	6

8.4 Discussion

Physical attractiveness is recognized as an important attribute in psychosocial well-being. The facial profile may be a particular source of concern for some individuals, with a considerably prominent or retrusive lower jaw being a significant reason for patients seeking orthognathic surgery. The appearance of the mandible in profile view is a potentially important determinant of perceived attractiveness and thereby knowledge of perceptions of attractiveness, in addition to average population values, is important for clinicians correcting facial deformities.

A large number of studies have been undertaken to assess the psychological factors involved in perceptions of facial attractiveness (Langlois et al., 2000). However, the purpose of the present investigation was to provide clinically relevant data by evaluating the perceptions of attractiveness for mandibular prominence, in order to provide objective evidence to guide clinicians involved in the treatment planning of patients requiring orthognathic surgery.

In order to determine and validate the correct facial proportions with which to plan clinical treatment, two sources of information are required (Naini et al., 2008). Firstly, population averages, which permit comparison of an individual's facial measurements and proportions to the population norms. Such data must be age, gender and ethnicity specific. Such data is available from anthropometric studies (Farkas et al., 1985) and long-term cephalometric growth studies of normal individuals (Broadbent et al., 1975). Secondly, the perceived attractiveness of the proportions must be confirmed by the judgement of patients and the lay public, and ideally compared to the judgement of treating clinicians. This was the main purpose of this investigation.

A potential limitation of the present study is that a type of observer bias may occur when Likert scales are used, where observers may have an unconscious tendency to avoid extreme categories, thereby essentially constricting the range of possible responses. However, if the worded categories are described clearly, the spectrum of genuine responses should be preserved, which is why the Likert scale is the preferred option in such studies (Langlois et al., 2000).

8.4.1 Hypothesis testing

The first part of the null hypothesis was that 'there is no effect of the type or degree/severity of the deviation of mandibular prominence on perceived attractiveness and desire for surgery. We reject this null hypothesis, as the results of this study found an effect of the type and degree/severity of the deviation of mandibular prominence on perceived attractiveness and desire for surgery. The second part of the null hypothesis was that ‘Likewise, there is no difference in the perception of orthognathic patients, laypeople and clinicians.’ We reject this null hypothesis, as the results of this study found a difference in the perceptions of the observer groups.

8.4.2 Influence of the degree and type of mandibular prominence of the image

On multivariate analysis the only variable that is found to have a significant effect on rating is the degree and type of mandibular prominence. The mean rating decreased by 0.20 of a level of the Likert scale for each 1 mm increase in the deviation in relation to the normal. Analysis of the entire dataset demonstrated that the mean rating for the ‘Normal’ image (i.e. image BC, with soft tissue pogonion on the true vertical line) was 1.83 levels of the Likert scale greater than for those images with negative deviation (mandibular retrusion) and 2.7 levels of the Likert scale greater than for those images with positive deviation (mandibular protrusion). The mean rating for images with positive deviation was 0.86 of a level of the Likert scale less than for images with negative deviation.

8.4.3 At what degree of mandibular prominence does the mandibular profile become so noticeable that patients want (or clinicians or laypeople recommend) surgical correction?

The results of this study demonstrate that mandibular retrusion up to -4mm and protrusion of up to 2mm is essentially unnoticeable for all three observer groups.

The extent of sagittal mandibular prominence above which observers began to desire surgery depended on whether the deviation was protrusive or retrusive, but did not differ much between the groups of observers. For mandibular retrusion, the values from which surgery was desired were approximately -8mm for patients and clinicians, and -9mm for laypeople. For mandibular prominence, the values from which surgery was desired were approximately 3mm for patients and laypeople but almost 5mm for clinicians.

8.4.4 Influence of observer group and professional status

Previous studies have found significant differences between the perceptions of facial profile attractiveness of orthodontists and maxillofacial surgeons compared with laypeople (Cochrane et al., 1999).

In the present study a significant difference between the observer groups was found (P=0.05), with laypeople giving on average 0.24 of a level of the Likert scale greater rating than patients. No significant differences were found between clinicians and patients (P=0.13) or clinicians and laypeople (P=0.70). The very existence of a mandibular discrepancy may lead to patients developing a greater sensitivity to noticeable differences in facial appearance from the 'ideal', which may explain their greater critical perception of mandibular prominence in comparison with the lay public. Although clinicians may develop enhanced critical faculties as a result of their training, it appears that in terms of mandibular prominence, their perceptions are similar to the other groups. Previous attractiveness studies on mandibular prominence have not used orthognathic patients as observers (Johnston et al., 2005a; Kuroda et al., 2009). The finding that orthognathic patients were more critical than laypeople, suggests that in future studies, greater emphasis might be put on evaluating the perceptions of patients as opposed to only a lay population.

Taking into account the orthognathic patient's skeletal Class, it was found that the most influential variable on rating was the degree of mandibular prominence. The ratings decreased by 0.21 of a level of the Likert scale for each unit deviation (2mm) in the mandible in relation to normal (P<0.001). Although there was a tendency for patients with skeletal Classes II and III to give lower ratings, no significant differences in the rating between the different skeletal Classes were detected (P=0.20). Interestingly, although patients were more critical in terms of attractiveness perception, no significant differences in the desire to have surgery were found between the three observer groups.

8.4.5 Desire for surgery

On multivariate logistic regression, observer age, gender, consideration of the importance of an attractive appearance and the degree of mandibular prominence featured as statistically significant factors on the desire for surgery. The odds of desire for surgery decreased by 2% for each year increase in observer age, was 50% greater for men, 48% greater for those who thought attractiveness was very important in relation to those that did not and was 45% greater for each mm change in the deviation of the mandible from normal. A difference was detected comparing mandibular protrusion and retrusion, with a 3-fold increase in desire for surgery for protrusion in relation to retrusion.

None of the other variables were shown to have any effect. In particular, no significant differences in the desire to have surgery were found between patients, laypeople and clinicians (P=0.39). No significant effect of skeletal Class was found in the orthognathic patient group.

8.4.6 Most attractive and least attractive images

The highest rated and thereby most attractive perceived image was BC, representing the idealised facial profile with soft tissue pogonion on the true vertical line and with the lower lip just posterior to the upper lip. Other highly rated images exhibited minor degrees of lower jaw retrusion of up to -4mm or very minor lower jaw prominence of 2mm. The lowest rated images demonstrated the most severe degrees of lower jaw protrusion (JM, HK) and retrusion (VF). The overall trend demonstrates that milder degrees of lower jaw retrusion and protrusion were rated as more attractive and greater degrees of deviation were rated as progressively less attractive, though the tendency was for lower jaw protrusion to be perceived as less attractive than retrusion.

Johnston et al., (2005) carried out an attractiveness study of mandibular prominence using profile silhouettes. They found that their image based on an SNB angle of 78 degrees was considered by the lay judges as the most attractive. Interestingly, the use of a cephalometric value such as the SNB angle to analyse a facial soft tissue variable such as mandibular prominence is open to debate, particularly as the SNB angle alters with changes in the S-N plane, and has no influence on the sagittal position or morphology of the lower lip or soft tissue chin. However, analysis of the silhouette image they described as rated highest demonstrates an almost straight profile, with the lower lip in line with a vertical line through subnasale, and the chin only just posterior to this line.

8.4.7 Comparison with previous studies

There is previous evidence that Class II profiles are regarded as less attractive than Class III profiles in some western countries (Czarnecki et al., 1993; Michiels and Sather, 1994; Cochrane et al., 1999; Johnston et al., 2005a), but the results of the present study do not provide confirmation, as overall mandibular protrusion appeared to be less attractive than mandibular retrusion. Perhaps a patient’s ability to posture the mandible forwards to disguise a Class II discrepancy may explain why Class II discrepancies may be better tolerated than Class III, though this is merely conjecture.

There is also evidence that the Class I profile is more attractive than Class II or Class III profiles (Kerr and O’Donnell, 1990; Phillips et al., 1995; Hönn et al., 2005; Ioi et al., 2007). The results of the present study confirm this, as the ‘ideal’ orthognathic (straight) profile, with soft tissue pogonion on the true vertical line (image BC), was rated as the most attractive image. Interestingly, in a Japanese population, Ioi et al. (2007) found that although observers tended to choose Class II profiles as more acceptable than Class III profiles for both males and females, patients with Class III profiles tended to seek surgical orthodontic treatment more often. The results of the present study demonstrate that although lower jaw deviations from the 'ideal' are noticeable from greater than approximately -4mm retrusion or 2mm protrusion, surgery is desired with relatively smaller protrusive deviations (from 3 to 5mm) compared to retrusive deviations (from -8 to -9mm).

The results of this investigation support previous empirical evidence that mild mandibular deviation in the sagittal plane is compatible with an attractive facial appearance, and an orthognathic profile is 'ideal'. For example, Gonzalez-Ulloa and Steven's zero-degree meridian (1968) is an aesthetic profile line, proposing that soft tissue pogonion should be on this vertical line dropped from soft tissue nasion, perpendicular to the Frankfort Horizontal plane, with subnasale on or close to this line. However, there is evidence that the zero-degree meridian line is based on facial profile analyses previously described in the Renaissance by Leonardo da Vinci (c. 1490) and Albrecht Dürer (c. 1528), both of whose work was based on anthropometric measurements of attractive individuals, rather than merely empirical (Naini, 2011).

Objective evidence from normative population samples (Subtelny, 1959; Worms et al., 1976; Farkas et al., 1985; Bhatia and Leighton, 1993), demonstrates that the angle of soft tissue profile convexity of the lower face tends to be with the lower jaw slightly retrusive; none of the normative population data demonstrates mandibular protrusion or a Class III profile as within normal limits. Such population data corroborates the results of the present study, in that mandibular protrusion appears to be less attractive and also leads to a greater desire for surgical correction than mandibular retrusion. An attractiveness study in a lay Japanese population, using a cropped profile photograph of a Japanese woman, also found that mandibular retrusion was generally more favoured than mandibular protrusion (Kuroda et al., 2009). However, it contradicts previous findings that Class II profiles are regarded as less attractive than Class III profiles (Czarnecki et al., 1993; Michiels and Sather, 1994; Cochrane et al., 1999; Johnston et al., 2005a).

8.5 Conclusions

From the results of this study, it is recommended that in treatment planning to alter the sagittal prominence of the mandible in an individual with an otherwise normal soft tissue facial profile, an 'ideal' sagittal position with soft tissue pogonion on or just behind a true vertical line through subnasale may be used, with the lower lip just posterior to the upper lip, although mandibular retrusion up to -4mm or protrusion up to 2mm were essentially unnoticeable.

Surgery was desired from mandibular protrusions of greater than 3mm (orthognathic patients and laypeople) and 5mm (clinicians), and retrusions greater than approximately -8mm.

The overall direction of aesthetic opinion appeared to be the same for all the observer groups; the greater the retrusion or prominence of the lower jaw, the less attractive the perceived attractiveness and the greater the desire for surgical correction.

Orthognathic patients were found to be more critical than laypeople, suggesting that in future studies, greater emphasis might be put on evaluating the perceptions of patients as opposed to only a lay population.

9 The influence of combined orthodontic-orthognathic surgical treatment on perceptions of attractiveness: A longitudinal study

9.1 Introduction

Facial appearance plays a significant role in human social life. It has been demonstrated that attractive individuals have a potential advantage over unattractive individuals because they are viewed as having better social skills, being more competent at work and possessing greater leadership qualities (Langlois et al., 2000). Attractive individuals also appear to possess higher self-esteem (O'Grady, 1989). As such, dentofacial deformities may have a negative impact on many aspects of life (Macgregor, 1990), and individuals with dentofacial deformities requiring orthognathic surgical correction appear to have a lower health-related quality of life and exhibit greater levels of anxiety and elevated interpersonal sensitivity (Cunningham et al., 2000; Lazaridou-Terzoudi et al., 2003; Ozgür et al., 1998).

Satisfaction after orthognathic surgery in former Class III patients has been shown to be high, with 78% of all patients rating postoperative outcomes with grades 8-10 on a visual analogue scale one year after surgery, and 73% recommending orthognathic surgery to other patients (Rustemeyer et al., 2010). This high satisfaction rate supported data from previous studies, in that long after undergoing orthognathic surgery, 84 to 92% of patients report satisfaction with their treatment, and indicate that they would undergo treatment again (Lazaridou-Terzoudi et al., 2003; Cunningham et al., 1996). However, this favourable attitude towards orthognathic surgery, which is an aesthetic and reconstructive procedure, does not generalize to 'cosmetic' procedures (Naini, 2011). Only 31% of patients having undergone 'cosmetic' surgical procedures report that they would consider other types of cosmetic surgery (Flanary et al., 1985).

Therefore, we know that facial appearance is important, that facial deformities affect an individual's quality of life and that orthognathic treatment appears to have a high patient satisfaction rate. However, no study to date has investigated the potential effects of orthognathic treatment on patient's perceptions of facial deformities. We do not know whether patient's perceptions change as a result of going through the process of combined orthodontic-orthognathic surgical treatment and whether going through such treatment makes patients more critical of deviations in facial appearance from the 'norm' than before they had the treatment.

The principal aim of this investigation was to quantitatively evaluate the influence of combined orthodontic-orthognathic surgical treatment on patients' perceptions of attractiveness and their desire for surgical correction.

9.2 Subjects and Methods

9.2.1 The Images

Two-dimensional facial profile silhouettes have been routinely used to assess the perceptions of facial profile attractiveness (Barrer and Ghafari, 1985; Johnston et al., 2005a; Ioi et al., 2005; Naini et al., 2011).

A facial profile silhouette image was created with computer software (Adobe® Photoshop® CS2 software; Adobe Systems Inc, San Jose, CA) (Naini et al., 2011). The image was then manipulated using the same computer software to construct an 'ideal' facial profile image with proportions (Naini, 2011) and soft tissue measurements (Farkas et al., 1984; Farkas et al., 1985; Farkas et al., 1986; Farkas and Kolar, 1987; Farkas, 1994; Naini, 2011) based on currently accepted criteria (see Figures 2.4 and 2.5).

Contrary to previous studies using cropped profile silhouettes (Johnston et al., 2005) or photographs (Kuroda et al., 2009), it was decided to display the complete profile silhouette image (Naini et al., 2011). Cropping the neck would lead to changes in the submental length (Johnston et al., 2005a; Kuroda et al., 2009), whereas in the present study the submental length remained constant throughout the images. It may be reasonable to argue that using the entire profile in this study created a more realistic image, particularly for non-clinical observers.

9.2.1.1 Profile image manipulation (incremental)

The mandibular prominence of the idealised profile image was altered in 2 mm increments from -16 to 12 mm, in order to represent retrusion and protrusion of the lower jaw respectively (see Figure 8.1).

9.2.2 The observers, questionnaire and rating method

9.2.2.1 Observers

From a group of 75 pre-treatment orthognathic patients recruited to a previous study (chapter 8), 50 orthognathic patients having completed orthognathic treatment, were recruited as observers in this study (Table 9.1), using the selection criteria described below:

- Selection criteria:
    - Primary concern had been facial appearance
    - No previous orthodontic or facial surgical treatment
    - No history of facial trauma
    - No severe psychological issues e.g. body dysmorphic disorder

Table 9.1 Observer demographics (CI, confidence interval)

Observer Group	Number	Mean age (years)	95% CI	Age range	Gender (% male)	Ethnicity (% White)
Orthognathic Patients	50	22	21.5 - 22.5	13 - 48	48%	60%

9.2.2.2 Questionnaire

After the initial consultation appointment, each observer was given a questionnaire and asked to provide the following information: age, gender, ethnic origin, right or left-handedness, how would you rate the attractiveness of *your* facial appearance, and how important do you think it is to have an attractive facial appearance. An instruction sheet accompanied the questionnaire, asking the observers to rate each image in terms of facial attractiveness using the following rating scale:

1. Extremely unattractive
2. Very unattractive
3. Slightly unattractive
4. Neither attractive or unattractive
5. Slightly attractive
6. Very attractive
7. Extremely attractive

In addition, observers were asked whether they would consider surgery to correct the appearance if this was their facial appearance (yes or no).

The images were placed in random order into Microsoft PowerPoint®. Each image was identified by a randomly assigned double letter in the top right corner of the screen (e.g. BC). A duplicate of one of the images in each group was used in order to assess intra-examiner reliability. Each observer sat undisturbed in the same room in front of the same computer and 17” flat screen monitor. The presentation and the images were created in such a way that each of the profile silhouette images, when viewed on the 17” flat screen monitor, had the same dimensions as a normal human head, based around an average lower anterior facial height. This would help to reduce the potential effect of image magnification or size reduction on the observer’s perception. Each observer examined the images in the PowerPoint® presentation by pressing the 'Page Down' button on the keyboard, in their own time.

9.2.2.3 Rating method

The Likert-type rating scale is largely accepted in the psychology literature as the most useful rating method (Langlois et al., 2000). The seven-point Likert scale described above was used by each observer to rate each image in terms of attractiveness. The data collected after this first consultation appointment formed the baseline data (T1). The patients then proceeded to undergo and successfully complete combined orthodontic-orthognathic surgical treatment. At the 6-month review appointment following removal of the orthodontic appliances and retainer wear, the observers completed the questionnaire again and underwent exactly the same data acquisition procedure using the same images in the same order in the same conditions, forming the follow up data (T2).

9.2.3 Statistical analysis

The baseline data were collected at the first consultation appointment (T1). The patients underwent combined orthodontic-orthognathic surgical treatment (single jaw or bimaxillary surgery). A second set of data was collected on a follow up visit, 6-months following debond of the orthodontic appliances (T2). The main outcomes were a measure of the patient's perceived attractiveness of the images and their desire for surgery. To evaluate the difference the orthognathic treatment made on the outcome measures for this group of patients, mixed linear regression was used for the variable 'attractiveness of the images' and mixed logistic regression for the variable 'desire for surgery'.

9.3 Results

Of the fifty patients acting as observers, 2 (4%) had skeletal Class I jaw relationships, 25 (50%) were skeletal Class II and 23 (46%) were skeletal Class III.

9.3.1 Reliability analysis

With analysis of variance with random effects for the observers, the variability between observers for replicated images DF and EE was significant ($P<0.001$): the value of the $F(49,50)$ statistic was 4.1 (T1). These results indicate little variation in the intra-observer ratings for these images. The intra-class correlations was 0.61 [95% confidence interval (CI) 0.43-0.78], representing good reliability. At T2, the variability between observers for the replicated images was also significant ($P<0.003$): the value of the $F(49,50)$ statistic was 2.2. The intra-class correlations was 0.38 [95% CI 0.14-0.61], representing good reliability.

9.3.2 Perceived attractiveness of images

The univariate and multivariate mixed linear regressions for rating are exhibited in tables 9.2 and 9.3.

Table 9.2 Univariate mixed linear regression for rating (adjusted with baseline)

	Overall		Positive deviations		Negative deviations	
Description	**Coef. – Interval**	**P value**	**Coef. - Interval**	**P value**	**Coef. – Interval**	**P value**
Age	-0.01 (-0.03, 0.00)	0.13	-0.01 (-0.03, 0.00)	0.14	-0.01 (-0.04, 0.01)	0.25
Gender (Male vs. Female)	-0.14 (-0.44, 0.16)	0.37	-0.24 (-0.53, 0.05)	0.10	-0.11 (-0.53, 0.30)	0.59
Ethnicity (White vs. non-White)	-0.19 (-0.49, 0.12)	0.23	-0.27 (-0.56, 0.03)	0.08	-0.12 (-0.55, 0.31)	0.58
Handedness (Left vs. Right)	-0.03 (-0.49, 0.44)	0.91	-0.19 (-0.65, 0.26)	0.41	0.17 (-0.47, 0.82)	0.60
Self-rating of appearance	0.12 (-0.24, 0.49)	0.51	0.21 (-0.14, 0.55)	0.25	0.08 (-0.43, 0.59)	0.77
Importance attractive appearance (Very important vs. Not very)	-0.03 (-0.36, 0.30)	0.84	-0.04 (-0.36, 0.28)	0.81	0.01 (-0.45, 0.47)	0.96
Observer's skeletal Class: Class III vs. Class I and II	0.34 (0.04, 0.63)	0.02	0.14 (-0.16, 0.43)	0.36	0.54 (0.14, 0.93)	0.008
Observer's vertical lower anterior face height	0.16 (-0.17, 0.48)	0.35	0.20 (-0.12, 0.51)	0.22	0.12 (-0.34, 0.57)	0.62
Degree of mandibular deviation (mm)	-0.07 (-0.09, -0.05)	0.001	-0.20 (-0.23, -0.16)	0.001	-0.17 (-0.20, -0.13)	0.001
Positive deviation (mandibular protrusion)	-0.57 (-0.72, -0.42)	0.001	-0.11 (-0.42, 0.20)	0.49	0.28 (-0.16, 0.71)	0.21
Negative deviation (mandibular retrusion)	0.44 (0.30, 0.58)	0.001	-0.01 (-0.03, 0.00)	0.14	-0.01 (-0.04, 0.01)	0.25
Treatment: Type of surgery (Single jaw vs. bimaxillary)	0.08 (-0.23, 0.40)	0.60	-0.24 (-0.53, 0.05)	0.10	-0.11 (-0.53, 0.30)	0.59

Table 9.3 Multivariate mixed linear regression for rating (adjusted with baseline)

	Overall		Positive deviations		Negative deviations	
Description	**Coef. – Interval**	**P value**	**Coef. - Interval**	**P value**	**Coef. - Interval**	**P value**
Observer's skeletal Class: Class III vs. Class I and II	0.38 (0.02, 0.75)	0.04			0.50 (0.11, 0.90)	0.01
Absolute value of deviation (mm)	-0.07 (-0.09, -0.05)	0.001	-0.20 (-0.23, -0.16)	0.001	-0.16 (-0.20, -0.13)	0.001
Treatment: Type of surgery (Single jaw vs. bimaxillary)	-0.14 (-0.52, 0.25)	0.48	-0.11 (-0.42, 0.20)	0.49	0.28 (-0.16, 0.71)	0.21

On mixed linear regression (Tables 9.2 and 9.3) only the observer's skeletal Class and the amount of deviation of the image were shown to have a significant effect on the ratings of attractiveness.

The mean difference in the change in rating between T1 and T2 was 0.50 of a level of the Likert scale greater for patients with skeletal Class III in relation to those with skeletal Classes I or II. The effect of deviation was rather similar for positive and negative deviations; the difference in the change in ratings between T1 and T2 decreased by 0.20 of a level of the Likert scale (95% CI -0.16 to -0.23; P<0.001) for each unit increase in a positive deviation and by 0.16 of a level of the Likert scale (95% CI -0.13 to -0.20; $P<0.001$) for each unit increase in a negative deviation.

After adjusting for these effects, no significant effect of type of surgical treatment (single jaw vs. bimaxillary surgery) was found on the ratings of attractiveness for these patients.

For mandibular retrusion, the mean difference in the change in the patients' rating between T1 and T2 was increased by 0.28 of a level of the Likert scale (95% CI -0.16 to 0.71; $P=0.21$) between the two treatment types (single jaw vs. bimaxillary surgery); i.e. single jaw surgery produced a greater difference than double jaw, but this difference was not significant.

For mandibular protrusion, the mean difference in the change in patients' rating between T1 and T2 was -0.11 of a level of the Likert scale (95% CI -0.42 to 0.20; $P=0.49$) between the two treatment types (single jaw vs. bimaxillary surgery); i.e. single jaw surgery produced a smaller difference than bimaxillary surgery. This difference was not significant.

9.3.3 Desire for surgery

The univariate mixed logistic regression for the binary outcome, desire for surgery, is demonstrated in table 9.4 and the multivariate logistic regression in table 9.5.

Table 9.4 Univariate mixed logistic regression for desire for surgery

	Overall		Positive deviations		Negative deviations	
Description	**OR**	**P value**	**OR**	**P value**	**OR**	**P value**
Age	1.02 (0.98, 1.05)	0.39	1.01 (0.97, 1.06)	0.53	1.01 (0.97, 1.06)	0.65
Gender (Male vs. Female)	1.55 (0.89, 2.71)	0.12	1.63 (0.77, 3.45)	0.21	1.72 (0.86, 3.45)	0.13
Ethnicity (White vs. non-White)	1.39 (0.78, 2.48)	0.26	1.78 (0.81, 3.87)	0.15	1.17 (0.57, 2.42)	0.67
Handedness (Left vs. Right)	1.06 (0.44, 2.56)	0.91	0.74 (0.25, 2.22)	0.59	1.29 (0.43, 3.86)	0.65
Self-rating of appearance	1.35 (0.68, 2.66)	0.39	1.47 (0.60, 3.64)	0.40	1.44 (0.62, 3.35)	0.40
Importance attractive appearance (Very important vs. Not very)	2.06 (1.13, 3.76)	0.02	2.49 (1.12, 5.55)	0.03	1.96 (0.91, 4.26)	0.09
Class III vs. Class I and II	0.63 (0.36, 1.10)	0.11	0.94 (0.44, 2.01)	0.87	0.48 (0.24, 0.96)	0.04
Observer's vertical lower anterior face height	1.00 (0.54, 1.86)	1.00	1.03 (0.46, 2.31)	0.95	0.95 (0.44, 2.08)	0.90
Degree of mandibular deviation (mm)	1.04 (1.02, 1.06)	0.001	2.89 (1.99, 4.18)	0.001	0.52 (0.44, 0.62)	0.001
Absolute value of deviation (mm)	1.31 (1.24, 1.38)	0.001	2.89 (1.99, 4.18)	0.001	1.91 (1.62, 2.26)	0.001
Treatment: Type of surgery (Single jaw vs. bimaxillary)	0.77 (0.42, 1.40)	0.39	1.16 (0.53, 2.54)	0.71	0.54 (0.26, 1.12)	0.10

Table 9.5 Multivariate mixed logistic regression for desire for surgery

	Overall		Positive deviations		Negative deviations	
Description	**OR**	**P value**	**OR**	**P value**	**OR**	**P value**
Gender (Male vs. Female)	1.85 (1.02, 3.33)	0.04				
Importance attractive appearance (Very imp vs. Not very)	2.20 (1.16, 4.17)	0.02				
Absolute value of deviation (mm)	1.31 (1.24, 1.38)	0.001	2.88 (1.99, 4.17)	0.001	1.93 (1.63, 2.28)	0.001
Treatment: Type of surgery (Single jaw vs. bimaxillary)	0.70 (0.38, 1.31)	0.27	1.23 (0.28, 5.28)	0.78	0.15 (0.04, 0.61)	0.009

On mixed logistic regression, the variables that were shown to have a significant effect on the likelihood of desire for surgery were: observer gender, the importance given to an attractive appearance and the amount of mandibular prominence of the images. The odds of desire for surgery were 85% greater for men (OR=1.85; 95% CI 1.02 to 3.3; P=0.04); more than doubled for those who attached importance to an attractive appearance (OR=2.2; 95% CI 1.16 to 4.17; P=0.02); approximately tripled for each unit increase in a positive deviation, i.e. mandibular prognathism (OR=2.88; 95% CI 1.99 to 4.2; P<0.001) and doubled for each unit increase in a negative deviation, i.e. mandibular retrognathism (OR=1.93; 95% CI 1.63 to 2.3; $P<0.001$) .

After adjusting for these effects, an effect of the type of surgical treatment (single jaw vs. bimaxillary surgery) was detected for the images with negative deviations only. The odds of desire for surgery were reduced by 85% for those patients who had undergone bimaxillary surgery in relation to those with single jaw surgery (OR=0.15; 95% CI 0.04 to 0.61; $P<0.01$); i.e. those who had bimaxillary surgery were 85% less likely to desire surgery when assessing profile images with mandibular retrognathia.

At T1, mandibular retrusion became noticeable at -4mm, and mandibular protrusion became noticeable at 2mm. The results remained unchanged at T2. The extent of sagittal mandibular prominence above which observers began to desire surgery depended on whether the deviation was protrusive or retrusive. For mandibular retrusion, the value from which surgery was desired was -9mm at T1 and -10mm at T2. For mandibular protrusion, the value from which surgery was desired was 3mm at T1 and 4mm at T2.

9.3.4 Most attractive and least attractive images

The highest rated and thereby most attractive perceived images at T1 were KC, BC, LD and CD. These images represented the idealized facial profile with soft tissue pogonion on the true vertical line (BC) and minor variations from -4mm to 2mm (Table 6). At T2, the order of the six most attractive images was virtually unchanged (Table 7), with only image BC (-2mm) being placed as most attractive and KC (0mm) as second most attractive. The most unattractive images were JM, HK, VF and GI, which represented severe degrees of mandibular protrusion and retrusion. This order did not change between T1 and T2 (Tables 9.6 and 9.7). There was mild variation in the overall ranking of the middle images.

Table 9.6 Mean observer ratings and confidence intervals, ordered from worse to best rating (T1 – pre-treatment); (positive values represent mandibular protrusion and negative values represent mandibular retrusion)

Rank	Image	Mandibular prominence (mm)	Mean	Std. Err	95% Confidence Interval		Median
16	JM	12	1.46	0.10	1.27	1.65	1
15	HK	10	1.66	0.10	1.46	1.86	2
14	VF	-16	1.86	0.14	1.58	2.14	2
13	GI	8	2.08	0.11	1.87	2.29	2
12	FD	6	2.40	0.13	2.14	2.66	3
11	RT	-12	2.82	0.16	2.49	3.15	3
10	DF	4	2.86	0.12	2.62	3.10	3
9	PD	-10	3.10	0.17	2.75	3.45	3
8	SB	-14	3.16	0.19	2.78	3.54	3
7	EE	4	3.26	0.15	2.96	3.56	3
6	OQ	-8	3.80	0.17	3.45	4.15	4
5	ME	-6	4.52	0.18	4.15	4.89	4
4	CD	2	4.60	0.16	4.28	4.92	4
3	LD	-4	5.56	0.12	5.32	5.80	5
2	BC	0	5.64	0.14	5.37	5.91	6
1	KC	-2	5.68	0.14	5.40	5.96	6

Table 9.7 Mean observer ratings and confidence intervals, ordered from worse to best rating (T2 – after treatment); (positive values represent mandibular protrusion and negative values represent mandibular retrusion)

Rank	Image	Mandibular prominence (mm)	Mean	Std. Err	95% Confidence Interval		Median
16	JM	12	1.64	0.10	1.44	1.84	2
15	HK	10	1.78	0.10	1.59	1.97	2
14	VF	-16	1.82	0.11	1.61	2.03	2
13	GI	8	2.08	0.12	1.84	2.32	2
12	SB	-14	2.30	0.15	2.00	2.60	2
11	FD	6	2.36	0.13	2.10	2.62	2
10	RT	-12	2.48	0.12	2.24	2.72	2
9	PD	-10	2.68	0.13	2.42	2.94	3
8	EE	4	2.74	0.15	2.44	3.04	3
7	DF	4	2.86	0.14	2.57	3.15	3
6	OQ	-8	3.22	0.14	2.94	3.50	3
5	ME	-6	3.84	0.15	3.55	4.13	4
4	CD	2	4.16	0.15	3.85	4.47	4
3	LD	-4	4.92	0.15	4.61	5.23	5
2	KC	-2	5.32	0.14	5.05	5.59	5
1	BC	0	5.38	0.16	5.06	5.70	6

9.4 Discussion

Orthognathic surgery typically enhances facial aesthetics and dental-occlusal function. Such positive changes may be expected, particularly in view of the relationship between facial attractiveness and self-concept (Berscheid and Gangestad, 1982) and mental health (Farina et al., 1977; Napoleon et al., 1980). However, the potential effects of orthognathic surgical treatment on patient's perceptions of facial deformities are not known.

In this study, we proposed to analyse the potential changes that may occur in the perception of attractiveness of pre-treatment orthognathic patients in the light of their experience of completing the combined orthodontic-orthognathic surgical treatment process, and the potential impact of such treatment on their subsequent judgements of attractiveness.

9.4.1 Hypothesis testing

The null hypothesis was that 'there is no effect of combined orthodontic-orthognathic surgical treatment on patients' perceptions of attractiveness and their desire for surgical correction. We do not reject this null hypothesis, as no significant difference was found on the perceptions of attractiveness of the observer group or their desire for surgical correction, when comparing before and after treatment.

9.4.2 Perceived attractiveness of images

Only the patient's skeletal Class and the amount of deviation of the image were shown to have a significant effect on the ratings of attractiveness. The effect of the observer's skeletal Class was only seen for negative deviations (mandibular retrusion); the difference between T1 and T2 was increased by 0.79 of a level of the Likert scale for skeletal Class III observers and increased by 0.24 of a level of the Likert scale for skeletal Classes I and II. The mean difference in the change in rating between T1 and T2 was 0.50 of a level of the Likert scale greater for patients with skeletal Class III in relation to those with skeletal Classes I or II.

The effect of deviation was rather similar for positive and negative deviations; the difference in the change in ratings between T1 and T2 decreased by 0.20 of a level of the Likert scale for each unit increase in a positive deviation and by 0.16 of a level of the Likert scale for each unit increase in a negative deviation. Interestingly, Hakman (1996) found differences in body image as a function of the specific type of dentoskeletal discrepancy with which patients presented, demonstrating greater dissatisfaction with facial features in individuals with mandibular retrognathia than in those with mandibular prognathism.

No significant effect of type of surgical treatment (single jaw vs. bimaxillary surgery) was found on the ratings of attractiveness for the orthognathic patients.

9.4.3 Single jaw versus bimaxillary surgery

For mandibular retrusion, the mean difference in the change in patients' rating between T1 and T2 was increased by 0.28 of a level of the Likert scale between single jaw and bimaxillary surgery. Therefore, single jaw surgery produced a greater difference than bimaxillary surgery, but this was not significant. For mandibular protrusion, the mean difference in the change in patients' rating between T1 and T2 was -0.11 of a level of the Likert scale between single jaw and bimaxillary surgery. Therefore, single jaw surgery produced a smaller difference than bimaxillary surgery, but this was not significant. Overall, no significant effect of type of surgical treatment (single jaw vs. bimaxillary surgery) was found on the ratings of attractiveness for these patients.

9.4.4 At what degree of prominence does the mandibular profile become so noticeable that patients want surgery to correct it? Does perception change as a result of treatment?

The results of this study demonstrate that mandibular retrusion up to −4 mm and protrusion of up to 2 mm is essentially unnoticeable in orthognathic patients. These results match those of the previous study (see chapter 8), which also included laypeople and clinicians as observer. From the results of the study in chapter 8 it was found that the extent of sagittal mandibular prominence above which observers began to desire surgery depended on whether the deviation was protrusive or retrusive but did not differ much between the three groups of observers. For mandibular retrusion, the values from which surgery was desired were approximately −8 mm for patients and clinicians and −9 mm for laypeople. For mandibular prominence, the values from which surgery was desired were approximately 3 mm for patients and laypeople but almost 5 mm for clinicians. The results of the present study demonstrate that at T1, mandibular retrusion became noticeable at -4mm, and mandibular protrusion became noticeable at 2mm. The results remained unchanged at T2. The extent of sagittal mandibular prominence above which observers began to desire surgery depended on whether the deviation was protrusive or retrusive. For mandibular retrusion, the value from which surgery was desired was -9mm at T1 and -10mm at T2. For mandibular protrusion, the value from which surgery was desired was 3mm at T1 and 4mm at T2.

9.4.5 Desire for surgery

The variables that were shown to have a significant effect on the likelihood of desire for surgery were observer gender, the importance given to an attractive appearance and the amount of mandibular deviation of the images. The odds of desire for surgery were 85% greater for men, more than doubled for those who attached importance to an attractive appearance and approximately tripled for each unit increase in a positive deviation, i.e.

mandibular prognathism and doubled for each unit increase in a negative deviation, i.e. mandibular retrognathism.

After adjusting for these effects, an effect of the type of surgical treatment (single jaw vs. bimaxillary surgery) was detected for negative deviations only. The odds of desire for surgery were reduced by 85% for those patients who had undergone bimaxillary surgery in relation to those with single jaw surgery; i.e. those who had bimaxillary surgery were 85% less likely to 'desire surgery' when assessing profile images with mandibular retrognathia.

9.4.6 Most attractive and least attractive images

The highest rated and thereby most attractive perceived images at T1 represented the idealized facial profile with soft tissue pogonion on the true vertical line (BC) and minor variations from -4mm to 2mm. At T2, the order of the six most attractive images was virtually unchanged, with only image BC (-2mm) being placed as most attractive and KC (0mm) as second most attractive. The most unattractive images represented severe degrees of mandibular protrusion and retrusion, and their order did not change between T1 and T2. There was mild variation in the middle images. Overall, the lowest rated images demonstrated the most severe degrees of mandibular protrusion and retrusion, the highest rated images represented the idealized facial profile and minor variations thereof, and there was very little change in perception between T1 and T2.

9.4.7 Influence of personal experience on judgements of attractiveness

In clinical psychology, the term perception refers to the neurophysiological processes, including memory, by which an individual becomes aware of and interprets external stimuli. In the context of attractiveness research, perception refers to the intuitive or direct recognition of an aesthetic quality, e.g. the physical attractiveness of a viewed facial profile (Naini, 2011).

Cooper et al. (2006) studied the development of the adult pattern of judgements of facial attractiveness in 4, 9 and 12-year-old children. Overall, the pattern of their results was consistent with the hypothesis that an individual's experience influenced their perceptions of attractiveness, with the proportions of the faces participants see in their everyday lives influencing their perceptions of attractiveness.

Another study from the same team (Cooper and Maurer, 2008) evaluated the explanation that average faces appear as both more familiar and more attractive because they resemble internal face prototypes formed from personal experience by examining the influence of recent experience on participants' subsequent judgements of attractiveness. Their results demonstrated that perceptions of attractiveness were influenced by recent experience, and suggested that internal face prototypes were constantly being updated by experience. The indication that adults' experience can alter their perceptions of attractiveness also suggests that experience may produce more long-term changes in the perceptions of attractiveness.

Adults from different cultural and ethnic backgrounds give similar ratings of facial attractiveness, even when they rate faces from an ethnic group with which they have had limited experience (Cunningham et al., 1995; Perrett et al., 1994; Rhodes et al., 2001). The perception of attractiveness is influenced by facial characteristics such as averageness, bilateral symmetry and secondary sexual characteristics (Rhodes, 2006). These influences remain consistent even when the ethnic and/or cultural background of the faces being rated differs from that of the observer. Despite these similarities in the perceptions of attractiveness, the existence of individual preferences is unquestioned (Hönekopp, 2006).

It has been theorised (Valentine and Bruce, 1986; Valentine, 1991) that the cognitive representation of faces is organised in an *n*-dimensional 'face space' centred on a prototypical face that represents the mean of an individual's experience, albeit with the possibility of there being separate prototypes for categories defined by age, gender or ethnic background. The structure of this face space directly mirrors an individual's unique experience with faces and changes over the course of his or her lifetime to reflect changes in experience.

Computer-generated average faces should theoretically more closely resemble prototypes in face space than do most naturally occurring faces. Average faces may be perceived as attractive because they resemble faces that are most often experienced and are therefore perceived as highly familiar.

Cooper and Maurer (2008) theorise that, similar to the way in which experience may lead to a preference for average faces over most individual faces, idiosyncratic experiences may lead to individual differences in the perception of attractiveness.

The only direct test of whether personal experience modifies the perception of attractiveness comes from recent laboratory studies of face adaptation. Brief exposure to a biased sample of faces can alter adults' perceptions of subsequently presented faces (Jeffery et al., 2006; Rhodes et al., 2003). For example, after adaptation to 10 compressed faces, adults' judge faces that have been slightly compressed to be more normal and more attractive than faces that have not been compressed (Rhodes et al., 2003). In addition to perceptions of attractiveness, similar adaptation influences the perceptions of gender, ethnicity, facial expression and facial identity (Jeffery et al., 2006; Rhodes et al., 2003).

Several authors have speculated that our everyday encounters with faces act in a similar way to these short-term adaptation effects, with changes in our experience altering our internal representations of faces and the prototype or norm to which they are compared (MacLin and Webster, 2001; Rhodes et al., 2003; Webster et al., 2004).

In light of the results discussed above relating to the psychology literature and potential changes in perception that may occur through personal experience, it may be conjectured that exposure to the information provided by orthodontists and maxillofacial surgeons, the time spent contemplating and deliberating on whether to have orthognathic treatment, repeated discussions regarding potential planned dentofacial alterations through orthognathic treatment, and finally going through and reflecting upon the results of treatment may have an effect on patients' perceptions, potentially making them more critical of deviations in facial appearance from the 'norm'.

Interestingly, and perhaps contrary to expectation and empirical/popular belief, the results of this current study demonstrate that going through the process of combined orthodontic-orthognathic surgical treatment does not appear to have any significant effect on patients' perceptions of facial profile attractiveness or the limits of mandibular sagittal deviation at which they would desire surgery.

However, it is relevant that orthognathic patients are already aware of their jaw and facial appearance when they initially attend, so their perceptions are not directly comparable to a layperson with no history of facial concerns. Hence it is understandable that their perceptions do not alter appreciably with orthognathic treatment – and it is useful to know that the clinician's information provision during treatment does not seem to unduly influence orthognathic patients by making them more critical of jaw/dentofacial deformities.

9.5 Conclusions

At T1, mandibular retrusion became noticeable at -4 mm, and protrusion at 2 mm. The results remained unchanged at T2. For mandibular retrusion, surgery was desired from -

9 mm at T1 and -10mm at T2. For mandibular protrusion, surgery was desired from 3mm at T1 and 4mm at T2.

No significant effect of type of surgical treatment (single jaw vs. bimaxillary surgery) was found on the ratings of attractiveness for these patients. The odds of desire for surgery were reduced by 85% for those patients who had undergone bimaxillary surgery in relation to those with single jaw surgery.

The lowest rated images demonstrated severe degrees of mandibular protrusion and retrusion, the highest rated images represented the idealized facial profile and minor variations thereof; there was little change in perception between T1 and T2.

Going through the process of orthognathic treatment does not appear to have any significant effect on patients' perceptions of facial profile attractiveness or the limits of mandibular sagittal deviation at which they would desire surgery.

Within the limitations of the cohort assessed and the timeframe involved in this study, the clinician's information provision during treatment does not seem to unduly influence orthognathic patients and does not make them more critical of jaw deformities.

10 General Discussion

10.1 Perceptions of attractiveness and threshold values of desire for surgery

The most individualistic, distinguishing physical feature of each person is the face; the representation of self and sense of identity resides to a great extent on facial appearance. The importance of facial appearance to normal psychosocial functioning and human happiness cannot be underestimated (Naini, 2011).

The definition of 'health', provided by the World Health Organization (WHO, 1948), is: 'Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity' (World Health Organization website, © 2003). Therefore, one of the primary aims of both aesthetic and reconstructive surgery is to improve the 'mental and social well-being' of patients by altering their facial appearance. Functional impairments are an obvious deterrent to health and thereby happiness; nevertheless, patients with facial deformities often cite their facial appearance as their greater concern.

The focus and objective of orthodontists and surgeons is to restore function and improve the health of their patients, whilst maintaining or improving the final aesthetic outcome. Due to the concerns of patients, aesthetic outcome should also be a primary concern for clinicians.

Dramatic drives in cost containment and quality assurance have also been implemented in healthcare, particularly in state funded systems. Objective outcome measurement systems are becoming more common throughout medicine. Clinicians have also found that these systems may be useful tools for self-monitoring and permitting objective surveillance of clinical outcomes. Facial aesthetic surgery has largely escaped such measures, as measurement of objective outcomes has been problematic. Orthognathic surgery, though within the same field, has had some measurement possible, though these have tended to concentrate on occlusal outcomes as opposed to facial aesthetic outcomes.

In addition to quality assurance of treatment results, data is required as to when a patient should receive surgical correction for a ‘deformity’, and at what stage the aesthetic differences of a facial parameter moves from being within the normal limits of variation for a population to being viewed as a ‘deformity’, which requires surgical correction or aesthetic improvement.

The work in this thesis was designed to provide an objective, quantitative evaluation of the influence of the severity of the disproportion of various facial parameters on perceived attractiveness. The purpose was to find the range of normal variability for each facial parameter, in terms of observer acceptance, and to find the threshold values of desire for surgical correction for the various facial parameters. Such data, as provided in this thesis, may be used as objective data for clinicians planning surgical correction of facial deformities, and may be presented to patients, particularly ‘borderline’ patients, as evidence for when observers view a visible difference as a deformity and when surgery tends to be desired. Additionally, such data may be used for quality assurance purposes by clinicians auditing the results of their treatment and may potentially be used to refuse patients that do not warrant treatment.

10.2 Strengths and weaknesses of the study

The most important aspect of any research project is the methodology. The results of this study are hoped to be a step in the right direction, in providing some form of objective and quantifiable data in relation to perceptions of facial attractiveness. Such results may be of use for clinicians, as discussed in the previous section. Nevertheless, such results must also be evaluated bearing in mind the potential shortcomings of the research methodology.

The created 'idealized' frontal facial images in chapters 3, 4 and 5 are essentially two-dimensional cartoon-type faces. The relevance of such images may be questioned in a study of facial attractiveness. Would an observer view such images in a similar way to a normal photographic image, or better still a true life three-dimensional image of a man or woman? Despite the difficulty with this approach, computer software to create a three-dimensional frontal facial image with 'idealized' facial proportions and measurements was not available at the time of image creation. The manipulation of two-dimensional photographs to create an idealized face was also impossible. To date, such software is still not available, though improvements are occurring at a rapid rate.

Both the frontal facial images and the profile silhouette image are based on white Caucasian proportions and normative values. Therefore, they are not generalizable to different ethnic groups and populations. As such, they may not be directly relevant, through they do provide an insight into how different ethnic groups view white Caucasian faces. It would be interesting to repeat the study using images from different ethnic groups. It is also arguable whether use of normative values based on North American Caucasians (based on Farkas normative data) are valid when assessed by UK observers, though a comparison of data analyzing facial appearance based US and UK populations (e.g. Riolo et al., 1974, compared with Bhatia and Leighton, 1993) demonstrate a difference in size but not of morphology (e.g. linear cephalometric measurements are generally larger in US populations but angular measurements are very similar to UK populations) (Naini, 2011).

The observer's anteroposterior jaw relationship, vertical face height and presence or absence of a facial asymmetry was analyzed for the orthognathic patient group based on formal clinical and cephalometric evaluation. However, for the laypeople and clinician groups these parameters were guesstimated from an informal appraisal of the individual's frontal facial and profile appearance, by visual assessment, undertaken by the author. It is therefore possible that individuals in the laypeople and clinician groups may have had mild Class II or III anteroposterior jaw relationships, which was not taken into account in the study.

During data collection, the observers looked at all the images in the various sections in one sitting. No time limit was set, though most observers completed the study within 30 to 45 minutes. It may be argued that observer fatigue may be relevant. Anecdotally, all the observer groups appeared interested in the study, with the patient group appearing the most interested in the study, judging by their questions and comments following completion of the questionnaire and study. Overall, it may be pertinent to keep such studies to only one parameter and thereby a limited number of images.

Another area where observer fatigue may have been relevant is that the reliability of the observers in some sections was only moderate, and it may be conjectured that the source of this may have been observer fatigue. However, albeit anecdotally, fatigue did not appear to be evident in the observers who took part in the study.

The recruitment of the observers also raises questions regarding the universal application of the results, even within the UK, as all the observers were based in and around the Greater London area. Future studies in different locations with a more heterogeneous population, perhaps even in different countries, may provide interesting comparative data.

The use of the Likert scale is largely acceptable in the psychology literature, but there is some argument as to whether a shortened scale from that used would have been more appropriate and easier to understand by the observers. Being an ordinal scale, the difference between 'slightly', 'very' and 'extremely' attractive or unattractive is impossible to quantify. For example, the jump between 'slightly' and 'very' attractive or unattractive may be quite substantial, whereas the jump between ‘very’ and ‘extremely’ attractive or unattractive may be quite small. Observers may have found it difficult to distinguish between ‘very’ and ‘extremely’ and it may be argued that leaving out the ‘extremely’ Likert items may have been better.

10.3 Future Considerations

Whilst the data within this thesis may be used as objective guidance in treatment planning, it will be necessary to provide similar data for facial parameters relating to the middle and upper thirds of the face. It would also be interesting to compare the perceptions of individuals from diverse ethnic backgrounds further, perhaps using populations from different countries as observers. Additional avenues of study also exist, particularly to use more sophisticated computer-imaging techniques to manipulate facial images, allowing more sophisticated experimental tests of what makes a face attractive.

11 Bibliography

Aquinas, T. (2006). Summa Theologiae. Cambridge, England: Cambridge University Press.

Aristotle. (2004). The Metaphysics. London, England: Penguin Classics.

Armstrong, R. (1987). The midpoint on a five-point Likert-type scale. *Percept Motor Skill* **64**, 359-62.

Arnett, G.W., Jelic, J.S., Kim, J., Cummings, D.R., Beress, A., Worley, C.M.Jr., Chung, B. and Bergman R. (1999). Soft tissue cephalometric analysis: diagnosis and treatment planning of dentofacial deformity. *Am J Orthod Dentofacial Orthop* **116**, 239-53.

Arpino, V.J., Giddon, D.B., BeGole, E.A. and Evans, C.A. (1998). Presurgical profile preferences of patients and clinicians. *Am J Orthod Dentofacial Orthop* **114**, 631-7.

Baker, B.W. and Woods, M.G. (2001). The role of the divine proportion in the esthetic improvement of patients undergoing combined orthodontic/orthognathic surgical treatment. *Int J Adult Orthodon Orthognath Surg* **16**, 108-20.

Barrer, J.G. and Ghafari, J. (1985). Silhouette profiles in the assessment of facial esthetics: a comparison of cases treated with various orthodontic appliances. *Am J Orthod* **87**, 385-91.

Baumgarten, A.G. (1989). Aesthetica (c.1750). Paris: L'herne.

Bell, R., Kiyak, H.A., Joondeph, D.R., McNeill, R.W. and Wallen, T.R. (1985). Perceptions of facial profile and their influence on the decision to undergo orthognathic surgery. *Am J Orthod* **88**, 323-32.

Berscheid, E. and Gangestad, S. (1982). The social psychological implications of facial physical attractiveness. *Clin Plast Surg* **9**, 289-96.

Bhatia, S.N. and Leighton, B.C. (1993). A Manual of Facial Growth: A computer analysis of longitudinal cephalometric growth data. New York: Oxford University Press.

Broadbent, B.H.Sr., Broadbent, B.H.Jr. and Golden, W.H. (1975). Bolton Standards of Dentofacial Developmental Growth. St Louis: Mosby.

Brontë, C. (1992). Jane Eyre (1847). London, England: Wordsworth Editions Ltd.

Brook, P.H. and Shaw, W.C. (1989). The development of an index of orthodontic treatment priority. *Eur J Orthod* **11**, 309-20.

Brown, E. and Perrett, D.I. (1993). What gives a face its gender? *Perception* **22**, 829–40.

Bruce, V., Burton, A.M., Hanna, E., Healey, P., Mason, O. and Coombes, A. (1993). Sex discrimination: How do we tell the difference between male and female faces? *Perception* **22**, 131–52.

Burke, P.H. (1971). Stereophotogrammetric measurement of normal facial asymmetry in children. *Hum Biol.* **43**, 536-48.

Cash, T.F. and Pruzinsky, T. (1990). Body images: Development, deviance, and change. New York: Guilford Press.

Chandrasekhar, S. (1987). Truth and Beauty: Aesthetics and Motivations in Science. Chicago: The University of Chicago Press.

Chen, A.C., German, C. and Zaidel, D.W. (1997). Brain asymmetry and facial attractiveness: facial beauty is not simply in the eye of the beholder. *Neuropsychologia* **35**, 471-6.

Clifford, M. and Walster, E. (1973). The effects of physical attractiveness on teacher expectation. *Sociol Educ* **46**, 248.

Cochrane, S.M., Cunningham, S.J. and Hunt, N.P. (1999). A comparison of the perception of facial profile by the general public and 3 groups of clinicians. *Int J Adult Orthodon Orthognath Surg* **14**, 291-5.

Cochrane, S.M., Cunningham, S.J. and Hunt, N.P. (1997). Perceptions of facial appearance by orthodontists and the general public. *J Clin Orthod* **31**, 164-8.

Coleman, G.G., Lindauer, S.J., Tüfekçi, E., Shroff, B. and Best, A.M. (2007). Influence of chin prominence on esthetic lip profile preferences. *Am J Orthod Dentofacial Orthop* **132**, 36-42.

Cooper, P.A., Geldart, S.S., Mondloch, C.J. and Maurer, D. (2006). Developmental changes in perceptions of attractiveness: a role of experience? *Dev Sci* **9**, 530-43.

Cooper, P.A. and Maurer, D. (2008). The influence of recent experience on perceptions of attractiveness. *Perception* **37**, 1216-26.

Cortella, S., Shofer, F.S. and Ghafari, J. (1997). Transverse development of the jaws: norms for the posteroanterior cephalometric analysis. *Am J Orthod Dentofacial Orthop* **112**, 519-22.

Cunningham, M.R., Roberts, A.R., Barbee, A.P., Druen, P.B. and Wu, C.H. (1995). Their ideas of beauty are, on the whole, the same as ours: Consistency and variability in the cross-cultural perception of female physical attractiveness. *J Pers Soc Psychol* **68**, 261-79.

Cunningham, S.J., Gilthorpe, M.S. and Hunt, N.P. (2000). Are orthognathic patients different? *Eur J Orthod* **22**, 195-202.

Cunningham, S.J., Hunt, N.P. and Feinmann, C. (1996). Perceptions of outcome following orthognathic surgery. *Br J Oral Maxillofac Surg* **34**, 210-13.

Czarnecki, S.T., Nanda, R.S. and Currier, G.F. (1993). Perceptions of a balanced facial profile. *Am J Orthod Dentofacial Orthop* **104**, 180-7.

Darwin, C.R. (2003). The Descent of Man (1871). London, England: Gibson Square Books Ltd.

Davidenko, N. (2007). Silhouetted face profiles: A new methodology for face perception research. *J Vis* **7**, 1–17.

De Smit, A. and Dermaut, L. (1984). Soft tissue profile preference. *Am J Orthod* **86**, 67-73.

Dürer, A. (1981). The Art of Measurement. San Francisco: Alan Wofsy Fine Arts.

Emerson, R.W. Beauty. In: Nature (1836). (1971a). The Collected Works of Ralph Waldo Emerson. Cambridge (Mass.): Harvard University Press.

Emerson, R.W. Beauty. In: The Conduct of Life (1860). (1971b). The Collected Works of Ralph Waldo Emerson. Cambridge (Mass.): Harvard University Press.

Farina, A., Fischer, E.H., Sherman, S., Smith, W.T., Groh, T. and Mermin P. (1977). Physical attractiveness and mental illness. *J Abnorm Psychol* **86**, 510-7.

Farkas, L.G. (1994). Anthropometry of the attractive North American White face. In: Farkas, L.G. (ed.). Anthropometry of the head and face (2nd Ed). New York: Raven Press.

Farkas, L.G. and Cheung, G. (1981). Facial asymmetry in healthy North American Caucasians. An anthropometrical study. *Angle Orthod* **51**, 70-7.

Farkas, L.G., Hreczko, T.A., Kolar, J.C. and Munro, I.R. (1985). Vertical and horizontal proportions of the face in young adult North American Whites: revision of neoclassical canons. *Plast Reconstr Surg* **75**, 328-38.

Farkas, L.G., Katic, M.J., Forrest, C.R., Alt, K.W., Bagic, I., Baltadjiev, G., Cunha, E., Cvicelova´, M., Davies, S., Erasmus, I., Gillett-Netting, R., Hajnis, K., Kemkes-Grottenthaler, A., Khomyakova, I., Kumi, A., Kgamphe, J.S., Kayo-

daigo, N., Le, T., Malinowski, A., Negasheva, M., Manolis, S., Ogetürk, M., Parvizrad, R., Rösing, F., Sahu, P., Sforza, C., Sivkov, S., Sultanova, N., Tomazo-Ravnik, T., Toth, G., Uzun, A. and Yahia, E. (2005). International anthropometric study of facial morphology in various ethnic groups/races. *J Craniofac Surg* **16**, 615–46.

Farkas, L.G., Katic, M.J., Hreczko, T.A., Deutsch, C. and Munro, I.R. (1984). Anthropometric proportions in the upper lip-lower lip-chin area of the lower face in young White adults. *Am J Orthod* **86**, 52-60.

Farkas, L.G., Kolar, J.C. (1987). Anthropometrics and art in the aesthetics of women's faces. *Clin Plast Surg* **14**, 599-616.

Farkas, L.G., Kolar, J.C. and Munro, I.R. (1986). Geography of the nose: a morphometric study. *Aesthetic Plast Surg* **10**, 191-223.

Farkas, L.G., Sohm, P., Kolar, J.C., Katic, M.J. and Munro, I.R. (1985). Inclinations of the facial profile: art versus reality. *Plast Reconstr Surg* **75**, 509-19.

Flanary, C.M., Barnwell, G.M. and Alexander, J.M. (1985). Patient perceptions of orthognathic surgery. *Am J Orthod* **88**, 137-45.

Flanary, C.M., Barnwell, G.M., VanSickels, J.E., Littlefield, J.H. and Rugh, A.L. (1990). Impact of orthognathic surgery on normal and abnormal personality dimensions: a 2-year follow-up study of 61 patients. *Am J Orthod Dentofacial Orthop* **98**, 313-22.

Foster, E.J. (1973). Profile preferences among diversified groups. *Angle Orthod* **43**, 34-40.

Galton, F. (1879). Composite portraits, made by combining those of many different persons in a single resultant figure. *J Anthropol Inst Great Britain and Ireland* **8**, 132–44.

Giddon, D.B. (1995). Orthodontic applications of psychological and perceptual studies of facial esthetics. *Semin Orthod* **1**, 82-93.

Giddon, D.B., Sconzo, R., Kinchen, J.A. and Evans, C.A. (1996). Quantitative comparison of computerized discrete and animated profile preferences. *Angle Orthod* **66**, 441-8.

Gonzalez-Ulloa, M. and Stevens, E. (1968). The role of chin correction in profileplasty. *Plast Reconstr Surg* **41**, 477-86.

Grammer, K. and Thornhill, R. (1994). Human facial attractiveness and sexual selection: The role of symmetry and averageness. *J Comparative Psychol* **108**, 233-42.

Green, C.D. (1995). All that glitters: a review of psychological research on the aesthetics of the golden section. *Perception* **24**, 937-68.

Hakman, E.C.J. (1996). Psychological studies in orthognathic surgery. In: DeBeaufort I, Hilhorst, M., Holm, S. (eds.) In the eye of the beholder: ethnics and medical change of appearance. Copenhagen: Scandinavian University Press.

Hall, D., Taylor, R.W., Jacobson, A., Sadowsky, P.L. and Bartolucci, A. (2000). The perception of optimal profile in African Americans versus white Americans as assessed by orthodontists and the lay public. *Am J Orthod Dentofacial Orthop* **118**, 514-25.

Herz-Fischler, R. (1998). A mathematical history of the golden number. New York: Dover Publications.

Hier, L.A., Evans, C.A., BeGole, E.A. and Giddon, D.B. (1999). Comparison of preferences in lip position using computer animated imaging. *Angle Orthod* **69**, 231-8.

Hockley, A., Weinstein, M., Borislow, A.J. and Braitman, L.E. (2012). Photos vs. silhouettes for evaluation of African American profile esthetics. *Am J Orthod Dentofacial Orthop* **141**, 161-8.

Holdaway, R.A. (1983). A soft tissue cephalometric analysis and its use in orthodontic treatment planning. Part I. *Am J Orthod* **84**, 1-28.

Holdaway, R.A. (1984). A soft tissue cephalometric analysis and its use in orthodontic treatment planning. Part II. *Am J Orthod* **85**, 279-93.

Hönn, M., Dietz, K., Godt, A. and Göz, G. (2005). Perceived relative attractiveness of facial profiles with varying degrees of skeletal anomalies. *J Orofac Orthop* **66**, 187-96.

Hönekopp, J. (2006). Once more: Is beauty in the eye of the beholder? Relative contributions of private and shared taste to judgments of facial attractiveness. *J Exp Psychol Hum Percept Perform* **32**, 199-209.

Hosoda, M., Stone-Romero, E.F. and Coats, G. (2003). The effects of physical attractiveness on job-related outcomes: A meta-analysis of experimental studies. *Personnel Psychol* **56**, 431-62.

Howe, T.N. (1999). Vitruvius: The Ten Books on Architecture. London: Cambridge University Press.

Hume, D. (1961). A Treatise on Human Nature (1738). London, England: JM Dent and Sons.

Hume, D. (1963). Of Tragedy. In: Essays, Literary, Moral and Political (1742). London, England: Oxford University Press.

Hume, D. (1963). The Sceptic. In: Essays, Literary, Moral and Political (1742). London, England: Oxford University Press.

Hume, D. (1995). Of the Standard of Taste (1757). In: Four Dissertations. London, England: Thoemmes Continuum.

Hungerford, M.W. (1890). Molly Bawn. London, England: Smith, Elder and Co.

Hutcheson, F. (2004). An Inquiry into the Original of our Ideas of Beauty and Virtue (1725). Indianapolis: Liberty Fund.

Ioi, H., Nakata, S., Nakasima, A. and Counts, A. (2005). Effect of facial convexity on antero-posterior lip positions of the most favored Japanese facial profiles. *Angle Orthod* **75**, 326-32.

Ioi, H., Nakata, S., Nakasima, A. and Counts, A. (2007). Influence of facial convexity on facial attractiveness in Japanese. *Orthod Craniofac Res* **10**, 181-6.

Jeffery, L., Rhodes, G. and Busey, T. (2006). View-specific coding of face shape. *Psychol Sci* **17**, 501-5.

Johnston, C., Hunt, O., Burden, D., Stevenson, M. and Hepper, P. (2005a). The influence of mandibular prominence on facial attractiveness. *Eur J Orthod* **27**, 129-33.

Johnston, D.J., Hunt, O., Johnston, C.D., Burden, D.J., Stevenson, M. and Hepper, P. (2005b). The influence of lower face vertical proportion on facial attractiveness. *Eur J Orthod* **27**, 349-54.

Jones, S. (1999). Almost like a Whale: The Origin of Species Updated. London, England: Doubleday.

Juggins, K.J., Nixon, F. and Cunningham, S.J. (2005). Patient- and clinician-perceived need for orthognathic surgery. *Am J Orthod Dentofacial Orthop* **128**, 697-702.

Kant, I. (1978). The Critique of Judgement. London, England: Oxford University Press.

Kerr, W.J. and O'Donnell, J.M. (1990). Panel perception of facial attractiveness. *Br J Orthod* **17**, 299-304.

Kiekens, R.M., van't Hof, M.A., Straatman. H., Kuijpers-Jagtman. A.M. and Maltha, J.C. (2007). Influence of panel composition on aesthetic evaluation of adolescent faces. *Eur J Orthod* **29**, 95-9.

Knight, H. and Keith, O. (2005). Ranking facial attractiveness. *Eur J Orthod* **27**, 340-8.

Koeslag, J.H. (1990). Koinophilia groups sexual creatures into species, promotes stasis, and stabilizes social behaviour. *J Theor Biol* **144**, 15-35.

Kuroda, S., Sugahara, T., Takabatake, S., Taketa, H., Ando, R. and Takano-Yamamoto, T. (2009). Influence of anteroposterior mandibular positions on facial attractiveness in Japanese adults. *Am J Orthod Dentofacial Orthop* **135**, 73-8.

Lamichane, M., Anderson, N.K., Rigali, P.H., Seldin, E.B. and Will, L.A. (2009). Accuracy of reconstructed images from cone-beam computed tomography scans. *Am J Orthod Dentofacial Orthop* **136**, 156.e1-6.

Langlois, J.H., Kalakanis, L., Rubenstein, A.J., Larson, A., Hallam, M. and Smoot, M. (2000). Maxims or myths of beauty? A meta-analytic and theoretical review. *Psychol Bull* **126**, 390-423.

Langlois, J.H., Ritter, J.M., Casey, R.J. and Sawin, D.B. (1995). Infant attractiveness predicts maternal behaviours and attitudes. *Dev Psychol* **31**, 466-72.

Langlois, J.H. and Roggman, L.A. (1990). Attractive faces are only average. *Psychol Sci* **1**, 115-21.

Langlois, J.H., Roggman, L.A., Casey, R.J., Ritter, J.M., Rieser-Danner, L.A. and Jenkins, V.Y. (1987). Infant preferences for attractive faces: rudiments of a stereotype? *Dev Psychol* **23**, 363-9.

Langlois, J.H., Roggman, L.A. and Musselman, L. (1994). What is average and what is not average about attractive faces. *Psychol Sci* **5**, 214-20.

Lazaridou-Terzoudi, T., Kiyak, H.A., Moore, R., Athanasiou, A.E. and Melsen, B. (2003). Long-term assessment of psychologic outcomes of orthognathic surgery. *J Oral Maxillofac Surg* **61**, 545-52.

Legan, H.L. and Burstone, C.J. (1980). Soft tissue cephalometric analysis for orthognathic surgery. *J Oral Surg* **38**, 744-51.

Likert, R. (1932). A technique for the measurement of attitudes. *Arch Psychol* **140**, 1–55.

Little, A.C., Penton-Voak, I.S., Burt, D.M. and Perrett, D.I. (2002). Evolution and individual differences in the perception of attractiveness: How cyclic hormonal changes and self-perceived attractiveness influence female preferences for male faces. In: Rhodes, G. and Zebrowitz, L.A. (eds). Facial attractiveness: Evolutionary, cognitive, and social perspectives. Advances in Visual Cognition, Volume 1. London, England: Ablex.

Lloyd, G.E.R. (Ed.). (1968). Aristotle: The Growth and Structure of his Thought. Cambridge, England: Cambridge University Press.

Macgregor, F. (1979). After plastic surgery: Adaptation and adjustment. New York: Praeger.

Macgregor, F.C. (1990). Facial disfigurement: problems and management of social interaction and implications for mental health. *Aesthetic Plast Surg* **14**, 249-57.

Macgregor, F. (1970). Social and psychological implications of dentofacial disfigurement. *Angle Orthod* **40**, 231-3.

MacLin, O.H. and Webster, M.A. (2001). The influence of adaptation on the perception of distortions in natural images. *J Electron Imaging* **10**, 100-9.

Maganzini, A.L., Tseng, J.Y. and Epstein, J.Z. (2000). Perception of facial esthetics by native Chinese participants by using manipulated digital imagery techniques. *Angle Orthod* **70**, 393-9.

Maple, J.R., Vig, K.W., Beck, F.M., Larsen, P.E. and Shanker, S. (2005). A comparison of providers' and consumers' perceptions of facial-profile attractiveness. *Am J Orthod Dentofacial Orthop* **128**, 690-6.

Marlowe, C. (1995). Doctor Faustus (1592). New York: Dover Publications.

Martin, J.G. (1964). Racial ethnocentrism and judgment of beauty. *J Soc Psychol* **63**, 59-63.

Mauchamp, O. and Sassouni, V. (1973). Growth and prediction of the skeletal and soft-tissue profiles. *Am J Orthod* **64**, 83-94.

McKoy-White, J., Evans, C.A., Viana, G., Anderson, N.K. and Giddon, D.B. (2006). Facial profile preferences of black women before and after orthodontic treatment. *Am J Orthod Dentofacial Orthop* **129**, 17-23.

Mejia-Maidl, M., Evans, C.A., Viana, G., Anderson, N.K. and Giddon, D.B. (2005). Preferences for facial profiles between Mexican Americans and Caucasians. *Angle Orthod* **75**, 953-8.

Meyer-Marcotty, P., Stellzig-Eisenhauer, A., Bareis, U., Hartmann, J. and Kochel, J. (2011). Three-dimensional perception of facial asymmetry. *Eur J Orthod* **33**, 647-53.

Michiels, G. and Sather, A.H. (1994). Determinants of facial attractiveness in a sample of white women. *Int J Adult Orthodon Orthognath Surg* **9**, 95-103.

Milton, J. (1942). Comus (1634). In: Comus and Some Shorter Poems of Milton. London, England: Harrap.

Miner, R.M., Anderson, N.K., Evans, C.A. and Giddon, D.B. (2007). The perception of children's computer-imaged facial profiles by patients, mothers and clinicians. *Angle Orthod* **77**, 1034-9.

Mommaerts, M.Y. and Moerenhout, B.A. (2011). Ideal proportions in full face front view, contemporary versus antique. *J Craniomaxillofac Surg* **39**, 107-110.

Montaigne, M. (1958). The Complete Essays of Montaigne. Frame, D.L. (Trans.). Chicago: Stanford University Press.

Moss, J.P., Linney, A.D. and Lowey, M.N. (1995). The use of three-dimensional techniques in facial esthetics. *Semin Orthod* **1**, 94-104.

Muzj, E. (1956). Biometric correlations among organs of the facial profile: A possible solution to the present crisis in orthodontics. *Am J Orthod* **42**, 827-57.

Naini, F.B. (2010). William Hogarth's The painter and his pug: defining the 'line of beauty'. *Arch Facial Plast Surg* **12**, 136-7.

Naini, F.B. (2011). Facial Aesthetics: Concepts and Clinical Diagnosis. Oxford, England: Wiley-Blackwell.

Naini, F.B., Cobourne, M.T., McDonald, F. and Donaldson, A.N. (2008). The influence of craniofacial to standing height proportion on perceived attractiveness. *Int J Oral Maxillofac Surg* **37**, 877-85.

Naini, F.B., Donaldson, A.N.A., Cobourne, M.T. and McDonald, F. (2012). Assessing the influence of mandibular prominence on perceived attractiveness in the orthognathic patient, layperson and clinician. *Eur J Orthod* **34**, 738-46.

Naini, F.B., Donaldson, A.N.A., McDonald, F. and Cobourne, M.T. (2012). Assessing the influence of chin prominence on perceived attractiveness in the orthognathic patient, layperson and clinician. *Int J Oral Maxillofac Surg* **41**, 839-46.

Naini, F.B., Donaldson, A.N.A., McDonald, F. and Cobourne, M.T. (2012). Assessing the influence of lower facial profile convexity on perceived attractiveness in the orthognathic patient, layperson and clinician. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology* **114**, 303-11.

Naini, F.B., Donaldson, A.N.A., McDonald, F. and Cobourne, M.T. (2012). Assessing the influence of mandibular and chin point asymmetry on perceived attractiveness in the orthognathic patient, layperson and clinician. *J Oral Maxillofac Surg* **70**, 192-206.

Naini, F.B., Donaldson, A.N.A., McDonald, F. and Cobourne, M.T. (2012). Influence of chin height on perceived attractiveness in the orthognathic patient, layperson and clinician. *Angle Orthod* **82**, 88-95.

Naini, F.B., Donaldson, A.N.A., McDonald, F. and Cobourne, M.T. The influence of combined orthodontic-orthognathic surgical treatment on perceptions of attractiveness: A longitudinal study. *Eur J Orthod* [In press].

Naini, F.B., Moss, J.P. and Gill, D.S. (2006). The enigma of facial beauty: esthetics, proportions, deformity, and controversy. *Am J Orthod Dentofacial Orthop* **130**, 277–82.

Napoleon, T., Chassin, L. and Young, R.D. (1980). A replication and extension of ‘physical attractiveness and mental illness’. *J Abnorm Psychol* **89**, 250-3.

Obwegeser, H.L. and Makek, M.S. (1986) Hemimandibular hyperplasia – hemimandibular elongation. *J Maxillofac Surg* **14**, 183-208.

O’Grady, K.E. (1989). Physical attractiveness, need for approval, social self-esteem, and maladjustment. *J Soc Clin Psychol* **8**, 62-9.

Orsini, M.G., Huang, G.J., Kiyak, H.A., Ramsay, D.S., Bollen, A.M., Anderson, N.K. and Giddon, D.B. (2006). Methods to evaluate profile preferences for the anteroposterior position of the mandible. *Am J Orthod Dentofacial Orthop* **130**, 283-91.

Ozgür, F., Tuncali, D. and Güler Gürsu, K. (1998). Life satisfaction, self esteem, and body image: a psychosocial evaluation of aesthetic and reconstructive surgery candidates. *Aesthetic Plast Surg* **22**, 412-9.

Park, Y.S., Evans, C.A., Viana, G., Anderson, N.K. and Giddon, D.B. (2006). Profile preferences of Korean American orthodontic patients and orthodontists. *World J Orthod* **7**, 286-92.

Pascal, B. (1966). Pensées (1670). London, England: Penguin Classics.

Patzer, G.L. (1985). The physical attractiveness phenomena (perspectives in social psychology). New York: Kluwer Academic/Plenum Publishers.

Peck, H. and Peck, S. (1970). A concept of facial esthetics. *Angle Orthod* **40**, 284–317.

Peck, S., Peck, L. and Kataja, M. (1991). Skeletal asymmetry in esthetically pleasing faces. *Angle Orthod* **61**, 43-8.

Pedretti, C. (2001). Leonardo da Vinci: Notebook of a Genius. Milan: Powerhouse publishing.

Perrett, D.I., Burt, D.M., Penton-Voak, I.S., Lee, K.J., Rowland, D.A. and Edwards, R. (1999). Symmetry and human facial attractiveness. *Evol Hum Behav* **20**, 295-307.

Perrett, D.I., May, K.A. and Yoshikawa, S. (1994). Facial shape and judgements of female attractiveness. *Nature* **368**, 239-242.

Phillips, C., Griffin, T. and Bennett, E. (1995). Perception of facial attractiveness by patients, peers, and professionals. *Int J Adult Orthodon Orthognath Surg* **10**, 127-35.

Plato. (1999). Phaedo. Oxford World's Classics. Oxford, England: Oxford University Press.

Plato. (2003). Symposium. London, England: Penguin Classics.

Rhodes, G. (2006). The evolutionary psychology of facial beauty. *Annu Rev Psychol* **57**, 199-226.

Rhodes, G., Jeffery, L., Watson, T.L., Clifford, C.W.G. and Nakayama, K. (2003). Fitting the mind to the world: Face adaptation and attractiveness aftereffects. *Psychol Sci* **14**, 558-66.

Rhodes, G., Proffitt, F., Grady, J. and Sumich, A. (1998). Facial symmetry and the perception of beauty. *Psychon B Rev* **5**, 659-69.

Rhodes, G., Roberts, J. and Simmons, L. (1999). Reflections on symmetry and attractiveness. *Psychol, Evol Gend* **1**, 279-95.

Rhodes, G., Sumich, A. and Byatt, G. (1999). Are average facial configurations attractive only because of their symmetry. Psyc*hol Sci* **10**, 52-8.

Rhodes, G., Yoshikawa, S., Clark, A., Lee, K., McKay, R. and Akamatsu, S. (2001). Attractiveness of facial averageness and symmetry in non-Western cultures: In search of biologically based standards of beauty. *Perception* **30**, 611-25.

Ricketts, R.M. (1982). The biologic significance of the divine proportion and Fibonacci series. *Am J Orthod* **81**, 351-70.

Riolo, M., Moyers, R.E., McNamara, J. and Hunter, W.S. (1974). An Atlas of Craniofacial Growth. Ann Arbor, MI: University of Michigan Center for Human Growth and Development.

Rosen, H. (1995). Aesthetic guidelines in genioplasty: the role of facial disproportion. *Plast Reconstr Surg* **95**, 463-9.

Rubenstein, A.J., Langlois, J.H. and Roggman, L.A. (2002). What makes a face attractive and why: The role of averageness in defining facial beauty. In: Rhodes, G.

and Zebrowitz, L.A. (eds). Facial attractiveness: Evolutionary, cognitive, and social perspectives. Advances in Visual Cognition, Volume 1. London, England: Ablex.

Rustemeyer, J., Eke, A. and Bremerich, A. (2010). Perception of improvement after orthognathic surgery: the important variables affecting patient satisfaction. *Oral Maxillofac Surg* **14**, 155-62.

Scheideman, G.B., Bell, W.H., Legan, H.L., Finn, R.A. and Reisch, J.S. (1980). Cephalometric analysis of dentofacial normals. *Am J Orthod* **78**, 404-20.

Schiller, J.F. (1983). On the Aesthetic Education of Man. Oxford, England: Oxford University Press.

Schwarz, A.M. (1961). Roentgenostatics: A practical evaluation of the x-ray headplate. *Am J Orthod* **47**, 561-85.

Shackelford, T.K. and Larsen, R.J. (1997). Facial asymmetry as an indicator of psychological, emotional, and physiological distress. *J Pers Soc Psychol* **72**, 456-66.

Shakespeare W. (1998). Love's Labour's Lost (c. 1595). London, England: Arden Shakespeare.

Shaw, W.C., Meek, S.C. and Jones, D.S. (1980). Nicknames, teasing, harassment and the salience of dental features among schoolchildren. *Br J Orthod* **7**, 75-80.

Shimomura, T., Ioi, H., Nakata, S. and Counts, A.L. (2011). Evaluation of well-balanced lip position by Japanese orthodontic patients. *Am J Orthod Dentofacial Orthop* **139**, e291-7.

Soh, J., Chew, M.T. and Wong, H.B. (2005). Professional assessment of facial profile attractiveness. *Am J Orthod Dentofacial Orthop* **128**, 201-5.

Snow, S.R. (1999). Esthetic smile analysis for maxillary anterior tooth width: the Golden Percentage. *J Esthetic Dent* **11**, 177-84.

Subtelny, J.D. (1959). A longitudinal study of soft tissue facial structures and their profile characteristics, defined in relation to underlying skeletal structures. *Am J Orthod* **45**, 481-507.

Theocritus. (1908). The Idylls of Theocritus and the Eclogues of Virgil. London, England: George Bell.

Thornhill, R. and Møller, A.P. (1997). Developmental stability, disease and medicine. *Biol Rev Camb Philos Soc* **72**, 497-548.

Tolstoy, L. (1924). The Kreutzer Sonata (1890). London, England: Oxford University Press.

Valentine, T. (1991). A unified account of the effects of distinctiveness, inversion, and race in face recognition. *Q J Exp Psychol-A* **43**, 161-204.

Valentine, T. and Bruce, V. (1986). The effects of distinctiveness in recognising and classifying faces. *Perception* **15**, 525-35.

Varlik, S.K., Demirbaş, E. and Orhan, M. (2010). Influence of lower facial height changes on frontal facial attractiveness and perception of treatment need by lay people. *Angle Orthod* **80**, 1159-64.

Wallace, L. (2005). The Prince of India (1893). New York: Polyglot Pr Inc.

Webster, M.A., Kaping, D., Mizokami, Y. and Duhamel, P. (2004). Adaptation to natural facial categories. *Nature* **428**, 557-61.

World Health Organization, definition of Health (2003). Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948. Available from: <http://www.who.int/about/definition/en/print.html> [17 December 2012].

Worms, F.W., Isaacson, R.J. and Speidel, T.M. (1976). Surgical orthodontic treatment planning: profile analysis and mandibular surgery. *Angle Orthod* **46**, 1-25.

Zaidel, D.W., Chen, A.C. and German, C. (1995). She is not a beauty even when she smiles: possible evolutionary basis for a relationship between facial attractiveness and hemispheric specialization. *Neuropsychologia* **33**, 649-55.

Zaidel, D.W. and Cohen, J.A. (2005). The face, beauty, and symmetry: perceiving asymmetry in beautiful faces. *Int J Neurosci* **115**, 1165-73.

Zebrowitz, L.A., Olson, K. and Hoffman, K. (1993). Stability of babyfaceness and attractiveness across the life span. *J Personality Soc Psychol* **64**, 453-66.